Public Document No. 31

TWENTY-SIXTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PARTS I. AND II.,

BEING PARTS III. AND IV. OF THE FIFTY-FIRST ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1914.

ENDING THE THIRTY-FIRST YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.

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Approved by
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MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PART I.

REPORT OF THE DIRECTOR AND OTHER OFFICERS.

PART II.

DETAILED REPORT OF THE EXPERIMENT STATION.

A RECORD OF THE THIRTY-FIRST YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.

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PART II.

Massachusetts Agricultural Experiment Station.

OFFICERS AND STAFF.

COMMITTEE.

STATION STAFF.

Administration.

WILLIAM P. BROOKS, Ph.D., *Director*.
JOSEPH B. LINDSEY, Ph.D., *Vice-Director*.
FRED C. KENNEY, *Treasurer*.
CHARLES R. GREEN, B.Agr., *Librarian*.
Mrs. LUCIA G. CHURCH, *Clerk*.
Miss GRACE E. GALLOND, *Stenographer*.

Agriculture.

WILLIAM P. BROOKS, Ph.D., *Agriculturist*.
HENRY J. FRANKLIN, Ph.D., *In Charge Cranberry Substation*.
EDWIN F. GASKILL, B.Sc., *Assistant Agriculturist*.

Chemistry.

JOSEPH B. LINDSEY, Ph.D., *Chemist*.
EDWARD B. HOLLAND, M.Sc., *Associate Chemist in Charge (Research Section)*.
FRED W. MORSE, M.Sc., *Research Chemist*.
HENRI D. HASKINS, B.Sc., *Chemist in Charge (Fertilizer Section)*.
PHILIP H. SMITH, M.Sc., *Chemist in Charge (Food and Dairy Section)*.
LEWELL S. WALKER, B.Sc., *Assistant Chemist*.
RUDOLF W. RUPRECHT, B.Sc., *Assistant Chemist*.
CARLTON P. JONES, M.Sc., *Assistant Chemist*.
CARLOS S. BEALS, B.Sc., *Assistant Chemist*.
WALTER S. FROST, B.Sc., *Assistant Chemist*.
JAMES P. BUCKLEY, Jr., *Assistant Chemist*.
JAMES T. HOWARD, *Inspector*.
HARRY L. ALLEN, *Assistant in Laboratory*.
JAMES R. ALCOCK, *Assistant in Animal Nutrition*.
Miss F. ETHEL FELTON, A.B., *Clerk*.
Miss ALICE M. HOWARD, *Clerk*.
Miss REBECCA L. MELLOR, *Clerk*.

Entomology.	Henry T. Fernald, Ph.D., *Entomologist.* Burton N. Gates, Ph.D., *Apiarist.* Arthur I. Bourne, A.B., *Assistant Entomologist.* Miss Bridie E. O'Donnell, *Clerk.*
Horticulture.	Frank A. Waugh, M.Sc., *Horticulturist.* Fred C. Sears, M.Sc., *Pomologist.* Jacob K. Shaw, Ph.D., *Research Pomologist.* John B. Norton, B.Sc., *Graduate Assistant.*
Meteorology.	John E. Ostrander, A.M., C.E., *Meteorologist.* E. K. Dexter, *Observer.*
Poultry Husbandry.	John C. Graham, B.Sc., *Poultry Husbandman.* Hubert D. Goodale, Ph.D., *Research Biologist.* Miss Fay L. Milton, *Clerk.*
Vegetable Pathology and Physiology.	George E. Stone, Ph.D., *Vegetable Physiologist and Pathologist.* George H. Chapman, M.Sc., *Research Vegetable Physiologist.* Orton L. Clark, B.Sc., *Assistant Vegetable Physiologist and Pathologist.* Miss Jessie V. Crocker, *Clerk.*
Veterinary Science.	James B. Paige, B.Sc., D.V.S., *Veterinarian.*

REPORT OF THE DIRECTOR.

WM. P. BROOKS.

ADMINISTRATION.

Station Staff.

From Oct. 1, 1912, to September, 1913, thus including the greater part of the director's leave of absence, the administrative duties of the office were faithfully and ably discharged by Mr. F. W. Morse, research chemist in agronomy, of our department of chemistry. It is a pleasure to testify not only to the fine tact and good judgment shown in a position necessarily somewhat difficult to fill, but as well to express appreciation of the effective initiative shown by Mr. Morse at a time particularly critical in the financial relations of the station to the State. The material increase in the annual provision made by the last Legislature for the support of the station, reported in detail under a topic considered later, is the best evidence of the quality of his work. It is a pleasure, also, to say that in all the phases of the work of the director's office the vice-director, Dr. J. B. Lindsey, took his accustomed hearty interest, gave most freely of his time, and contributed no little to its successful administration. The splendid *esprit de corps* shown by all the members of the staff should also be mentioned. Each fully met the responsibilities of his position, and more; and it is in a sense invidious to recognize especially the services of the first clerk of the administrative department, Mrs. L. G. Church, and the assistant agriculturist, Mr. E. F. Gaskill, to whom, however, inevitably fell an unusual share of the duties usually devolving upon the director and agriculturist.

On the resumption of my duties as director on September 1 Professor Morse was once more able to devote his entire time to the important lines of research connected with the nutrition of asparagus and the cranberry, and the specific effects of certain fertilizer chemicals upon the soil, in which he has been engaged for the past few years.

The station has been fortunate in retaining the services of all the senior members of its staff. This has been strengthened and the scope of its work increased by the appointment on February 1 of H. D. Goodale, Ph.D., as research biologist in the poultry department. Other new appointments in the same department are Mr. J. W. Sayer, foreman, Mary R. Kingsbury and Fay L. Milton as clerks, the latter replacing Miss Kingsbury in September. An added assistant was rendered necessary by the increase in the amount of work connected with the inspection of commercial fertilizers, and W. S. Frost, B.Sc., of Tufts College, was appointed assistant chemist. John B. Norton, B.Sc., University of Vermont, was appointed to the vacancy as graduate assistant in horticulture in May. Miss Lina E. Fisher, who had given one-half her time to the clerical work of the department of chemistry, was transferred in October to the chemical department of the college, her place being taken by Miss Rebecca L. Mellor, who similarly gives one-half her time to the clerical work of the department of chemistry. Mr. James C. Reed, who for several years had served as assistant, a considerable portion of the time in the research section, resigned in June to accept a position as chemist in connection with the manufacture of commercial feeds. His place was filled by the appointment of Mr. J. P. Buckley, who had taken courses of study in the Massachusetts Institute of Technology.

Geo. H. Chapman, research vegetable physiologist and pathologist, was granted eight months leave of absence, beginning September 1. Mr. Chapman will spend most of his time in study abroad. Orton L. Clark, B.Sc., was at the same time employed in the department, and is engaged in important lines of research.

Maintenance.

At the beginning of the fiscal year, Dec. 1, 1912, the increase in the State appropriation for the support of the experiment station from $10,500, at which figure it had stood for many years, to $15,000, as provided by the Legislature of that year, became effective. The Legislature of 1913 passed an act increasing the annual State appropriation for investigation $5,000 per year for five years, beginning Dec. 1, 1913.

Other sources of income to the station have remained practically unchanged, and the gradual increase in the amount received from the State provided by the act just referred to will hardly suffice to enable the station to increase the scope of its work with the constantly broadening horizon and to meet the rapidly increasing demands upon it for service.

The federal appropriations have remained unchanged for three years. The amounts received from products sold, for labor for other departments of the institution, for chemical work and cow testing are subject to variation from year to year and cannot be estimated with entire safety in making up the annual budget. It is true, however, that the aggregate usually reaches a considerable sum. The amounts received during the past year are shown in the general table. The receipts from the sale of cranberries produced at the substation in Wareham were exceptionally large, as the crop was the most abundant produced since it has been the property of the station.

Attention is called to the fact that the fees received for the inspection of commercial fertilizers and the State appropriation for the execution of the feed law are almost entirely required in meeting the expenses connected with our control work. The amended laws now upon the statute books, however, provide that unexpended balances may be used in case of the fertilizer control work for investigations in relation to the use of manures and fertilizers, and in the case of the feed law for investigations in relation to foodstuffs and the feeding of farm animals. The balances so expended during the past year have been: —

From the fertilizer inspection, ...	$516 16
From the feed law appropriation, ...	350 00

Total Revenue for the Fiscal Year Dec. 1, 1912, to Dec. 1, 1913.

State appropriation,	$15,000 00
Federal appropriations: —	
Hatch fund,	15,000 00
Adams fund,	15,000 00
Agricultural department sales and labor,	2,740 01
Chemical department analytical work, cow testing, etc.,	9,038 81
Fertilizer law, analysis fees,	10,580 00
Feed law, State appropriation,	6,000 00
Cranberry substation: —	
Sales of fruit,	5,671 82
Sales of vines,	19 65
Meteorological observations, scientific services, etc.,	193 03
Total,	$79,243 32

The total amount available for investigation is about $16,000 less than the above total, about that sum being required for the execution of the feed and fertilizer laws.

The treasurer's report in full will be found on pages 40*a* and 41*a*.

PUBLICATIONS.

The following is a complete list of the station publications for the fiscal year just ended: —

Annual Report.

Twenty-fifth Annual Report: Part I., 240 pages; Part II., 97 pages.

Separata from Annual Report.

Report of the Cranberry Substation, 28 pages.
Report of the Botanist, 104 pages.
Report of the Entomologist, 21 pages.
The Inheritance of Blossom Color in Beans, 24 pages.

Bulletins.

No. 143. Inspection of Commercial Fertilizers, by H. D. Haskins, L. S. Walker, C. P. Jones and C. L. Beals; 93 pages.
No. 144. The Relation of Light to Greenhouse Culture, by G. E. Stone; 40 pages.
No. 145. Record of the Station Dairy Herd and the Cost of Milk Production, by J. B. Lindsey; 31 pages.
No. 146. Inspection of Commercial Feedstuffs, by P. H. Smith and C. L. Beals; 61 pages.

Circulars.

No. 35. Poultry Manures, their Treatment and Use; revision of No. 22; 4 pages.

Meteorological Reports.

Twelve numbers, 4 pages each.

Publications Available for Distribution.

Bulletins.

No. 33. Glossary of Fodder Terms.
No. 115. Cranberry Insects.
No. 123. Fungicides, Insecticides and Spraying Directions.
No. 130. Meteorological Summary — Twenty Years.
No. 133. Green Crops for Summer Soiling.
No. 134. The Hay Crop.
No. 137. The Rational Use of Lime.
No. 139. Tomato Diseases.[1]
No. 144. The Relation of Light to Greenhouse Culture.
No. 145. The Cost of Milk Production.
No. 148. On the Diagnosis of Infection with Bacterium Pullorum in the Domestic Fowl.[2]
No. 149. A Study of Variation in Apples.
No. 150. Reports on Experimental Work in Connection with Cranberries.
No. 151. The Determination of Acetyl Number.
No. 152. The Digestibility of Cattle Foods.
No. 153. A Summary of Meteorological Records for Twenty-five Years.
No. 154. Alfalfa.
No. 155. New Fertilizer Materials and By-products; and Cocoanut Meal.
Nos. 131, 135, 140. Inspection of Commercial Fertilizers for the Years 1909, 1910 and 1911.
Nos. 132, 136, 139, 142. Inspection of Commercial Feedstuffs for the Years 1909, 1910, 1911 and 1912.

Annual Reports.

Hatch Experiment Station: Fifth (1893); Sixth (1894); Tenth (1898); Eleventh (1899); Twelfth (1900); Thirteenth (1901); Fourteenth (1902); Fifteenth (1903); Sixteenth (1904); Seventeenth (1905).

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[1] Edition nearly exhausted.

[2] Bulletins 148–155 were not printed until after the end of the year covered by this report; but are here included, as the date of printing the report is later than the dates of printing these bulletins.

Massachusetts Agricultural Experiment Station: Twentieth (1908); Twenty-first, Part II. (1909); Twenty-second, Part I. (1910); Twenty-third, Part I. (1911); Twenty-fourth, Parts I. and II. (1912); Twenty-fifth, Part I. (1913).

Circulars.

No. 20. Lime in Massachusetts Agriculture.
No. 27. Seeding Mowings.
No. 29. Soil Analysis.
No. 36. Poultry Manures, their Treatment and Use.
No. 37. Green Manuring and Cover Crops.
No. 38. Cabbage, Cauliflower, Turnip, Rape and Other Crucifers.
No. 40. Downy Mildew of Cucumbers.
No. 41. The Control of Onion Smut.
No. 42. Fertilizers for Potatoes.
No. 43. Cut Worms.
Home Mixed Fertilizers.
Orchard Experiment.
Fertilizers for Corn.
Composition and Digestibility of Fodder Articles; Composition of Fertilizer Materials, Refuse Substances, Garden Crops and Soils. (A separate from the twenty-third annual report.)
For distribution in Massachusetts, Bulletin No. 180 of the Connecticut Agricultural Experiment Station: Studies on the Tobacco Crop of Connecticut, by Director E. H. Jenkins.

The plan followed in the distribution of our publications during the past year has been the same as for several years, and is described in the twenty-fourth annual report. The demand, however, has greatly increased and the size of editions must be correspondingly increased. The edition of a number of the bulletins has recently been entirely exhausted within a few weeks after publication, while requests for them will continue for months and even years. With the increase in interest in scientific agriculture and country life, with the multiplication of institutions in which agriculture is taught, and of those, both public and private, devoted to agricultural experiment and demonstration, with the fuller development of agricultural extension service under the recently enacted Lever bill, and the organization of the county league or agent system, is sure to come a yet more rapid growth in demand for station publications.

Thus far it has been the policy in this station, as it is in most, to send publications on request to citizens of other States. This is sound policy from the standpoint of publication efficiency, and fully justified by the fact that a large share of the funds for the support of our experiment stations comes from the federal treasury. The fullest reciprocity is desirable, for in most cases results obtained in one State find almost equal application in numerous others.

Still another cause of increased demand is found in connection with schools which teach agriculture, which, in not a few cases, make use of bulletins in their class work, for which purpose a large number of duplicate copies is often requested. It has thus far been our policy to meet this demand also when possible.

If we are to continue in the future the generous policy of the past, and to meet the increasing demands which have been referred to, it will become necessary either to greatly increase the expenditure for publication or to curtail circulation in certain directions. It is believed that the latter course can be followed without disadvantage to any real interest. A careful study of the situation as affected by the existing law governing the publication of our annual reports has led to the conclusion that there is wasteful circulation and some duplication, resulting from the inclusion of the formal technical parts of our reports in the annual reports of the secretary of our State Board of Agriculture; and a plan which shall at the same time avoid such waste and duplication and bring our method of publication into conformity with the plan recommended by the American Association of Agricultural Colleges and Experiment Stations has been embodied in an amended act which will be brought before the Legislature of 1914. The act as amended leaves the determination of the size of the editions, within a specified maximum, to the director, who will be able to adapt any edition to the prospective demand, which varies widely for different publications. The advantages of the act as amended are so clear that its passage is confidently looked for.[1]

A list of such of our publications as can still be sent on request will be found on page 7*a*.

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[1] This act was passed before the date of printing.

Mailing Lists.

The fullest economy in the matter of the circulation of station publications is possible only when the mailing lists are kept fully alive. Very frequent revisions are necessary. It is true that the United States postal regulations state that postmasters must return all station publications not delivered, but in a very large proportion of cases this regulation is not complied with. It has been our practice, therefore, not only to make corrections whenever reported, and to drop names when publications are returned, but to fully revise all Massachusetts lists once in two years. Under these conditions the number of addresses which we find should be dropped because of death, removal or other causes is surprising. It must average about 20 to 25 per cent. of the total. There is also an astonishing number of changes shown to be necessary in every revision. These are due in many cases to removal, but in not a few instances to changes in post offices. It is estimated that in the last revision about one-half of the addresses remaining required change. There is much difference in the number for different post offices, a difference no doubt traceable to difference in the faithfulness with which the postal regulation above referred to is complied with. The table shows the nature of the lists which we at present maintain and the numbers in the several classes.

Residents of Massachusetts (general),	13,325
Residents of other States (general),	557
Residents of other States (general and technical),	765
Residents of foreign countries,	154
Newspapers,	513
Libraries,	343
Exchanges,	189
Cranberry growers,	1,710
Beekeepers,	3,719
Feed and fertilizer dealers,	310
Greenhouse growers,	1.848
Meteorological,	386
United States Department of Agriculture Official List,[1]	2,794
Total,	26,613

[1] Publications are not as a rule sent to all on this list but only to presidents, directors, libraries and specialists likely to be interested.

The general list, as will be seen, includes 13,325 names. It is felt that sending all publications except those of a highly technical character (which we always give a much more restricted circulation) to all the persons on the list doubtless involves considerable waste. Our agriculture is highly specialized in many sections. Our publications on specialized branches of agriculture are of interest only to those engaged in them, and it is our policy to increase the number of special lists with a view to a better and more economical, and at the same time more effective, circulation of our various publications.

Extension Service.

The experiment station is still called upon for a large amount of service which is really of the character of extension. The extension service of the college, under Prof. W. D. Hurd, is now handling an enormous number of requests for information and advice; but the appreciation of and call for such assistance has grown with such rapidity that there has been no appreciable decrease in the number of calls upon the specialists of the station staff. Correspondence still makes heavy demands upon their time. They still accept many invitations for public lectures and demonstrations all over the State. It is the policy in the institution that this work shall be done mainly by members of the extension service staff. The specialists of the experiment station must naturally always be in demand for addresses on certain subjects, but since it is recognized that meeting many engagements of this character interferes greatly with research efficiency, such addresses should be restricted within narrow limits.

Needs of the Station.

Attention has been called to the fact that the gradual increase in the amount appropriated by the State for the support of the experiment station is not adequate; but as the act of the Legislature making provision for such increase was made with a fairly definite understanding that further increase would not be asked for within the period covered by the act, it would be contrary to sound policy to ask an increase in appropriation for general purposes. There are, however, two needs so pressing that they must be stated and should be provided for as soon as possible. These are additional land and an appropriation for demonstration on selected farms throughout the State.

Land. — The area available for experiment in the departments of agriculture and horticulture is far too small. There has been no increase for many years except by lease, a system which has numerous disadvantages which are referred to later. Meanwhile, the science of agriculture has gained rapidly. New discoveries constantly widen our horizon. Investigations are now needed in fields undreamed of not many years ago. Soil biology, soil physics, the influence of toxins, the theory of antagonism, are a few among the many fields in which work is urgently needed.

The station now leases four different areas for experiment, — two and one-half acres in Concord for work with asparagus, which has been held for seven years on an indefinite lease; six and one-half acres in South Amherst for orchard experiments, leased for ten years, seven of which have already passed; eighteen acres adjoining the station grounds in Amherst, leased for orchard experiments in 1912 for twenty years; and two acres, also in Amherst but not immediately adjoining the station grounds, which we have used for one year on a four-year lease.

In the case of the areas in Concord and South Amherst there has already been paid for the use of the land sums in each case considerably in excess of the figure at which these properties could have been purchased. The same will be true of one at least of the other areas mentioned within a very few years. The policy of leasing is not, therefore, a sound one from the standpoint of economy. There are, however, much more important objections, chief among which is the uncertainty of tenure for the full period during which the experiment should continue. This cannot be determined in advance. In the case of the South Amherst area it was thought when the lease was executed that the specific problem for which it was desired could be solved within the ten years, but it is already apparent that it would be a great advantage to continue the varying fertilizer and cultural treatments during a much longer period, in order to determine more fully the ultimate effects upon the apple, which is a very long-lived tree. We already know that the present owner (who has purchased the property since we hired it) will not renew at any figure which the station can afford to pay. We shall find ourselves, therefore, three years hence, compelled to turn over to the owner a piece of property worth several times what it was when we leased it, having meanwhile paid the former owner and to the present one a total sum considerably in excess of the value when the land came under our management.

The situation as affecting the Concord land, planted to asparagus (also a long-lived crop), is from a business point of view entirely similar; but as the lease of this land is indeterminate it is yet worse from an experimental viewpoint, for the owner may terminate the lease at any time. Fortunately, such action on his part is not now anticipated, for he is very greatly interested in the experiment; but we are entirely dependent upon his good will.

Another point to be considered is that the value of areas suitable for our needs is steadily appreciating. Land can probably never be bought at lower prices than now. It would seem the part of wisdom to take early action.

Not only do sound business considerations urge this course, but the need becomes every year more desperate as the area which has been available for station use is more and more encroached upon as the result of the growth of the educational side of the institution. The location of buildings has already rendered far less valuable or entirely valueless for our use three fields in which important lines of inquiry were in progress, and other locations which will have a similar effect are in prospect.

Still another point has an important relation to our need. With the great increase in the number of students who room in all parts of the town, and with the erection of new buildings in different parts of the campus between which large numbers of students must pass in going to and from classes, it has become almost impossible to prevent trespass, as a student in a hurry is disposed to cut corners, which means crossing the plots. It seems to the director, and to all members of the station staff familiar with the situation, and especially to those directly interested in the use of land, that a candid consideration of the facts stated, and of others which might be presented, leads inevitably to the conclusion that more land should be purchased at the earliest possible moment.

Demonstration. — There are two rather distinct types of demonstration: the one having for its object teaching a lesson concerning the value of a line of practice, already fully established as sound, for the purpose of impressing the farmers in the locality in which it is located with the fact of its importance to them; the other designed to test the validity of results of research or experiment in our own or other stations under varying conditions affecting soil, local climate and economic result upon the farms in different sections of the State.

Demonstration of the first kind is properly the function of the extension service; that of the second kind is more legitimately the work of the experiment station. for it is experimental in nature and will result in broadening the field of knowledge. New and more or less untried methods or modifications of old methods, new crops or varieties, new insecticides and fungicides, new fertilizers, or new methods of employing fertilizers, are a few among many subjects which may appropriately be made matters for station demonstration.

There is one line of experimental demonstration in particular which is urgent, both because of its vital importance in the agriculture of the State and because the station has been strongly urged to undertake it. I refer to methods of pasture improvement. The experiment station has obtained some very striking results in the use of fertilizers. It is important that the extent to which similar results may be anticipated on different types of soil be investigated; and that the question as to whether pasture improvement by such use of fertilizer or by other methods which are in need of investigation can be made profitable. The pastures of the State stand in great need of improvement. Our live stock ranges over wide areas to obtain, in too many cases, only a scanty subsistence. The production of milk in the State has rapidly fallen off during recent years, no doubt in considerable measure because of the poor condition of our pastures.

Moreover, the high prices now ruling for meats make it seem highly probable that the time has come when, with intelligent improvement of pastures, the State might wisely produce a much larger share of the meat consumed by its inhabitants. It seems entirely possible that steers and sheep can be profitably fattened in the State even if they can be reared to the fattening age more cheaply in other parts of the country. There is, however, a question whether even the production of well-bred stock to the fattening age may not be successfully carried on. Our soils and climate are admirably adapted to the production of pasture forage. An appropriation for the purpose of undertaking extensive demonstration experiments in pasture improvement is highly desirable.

The Attitude of the Station toward Private Work.

That the most important function of the experiment station is the public service is generally recognized. It is also generally recognized that its principal work should be investigation, with a view to gaining new knowledge of fundamental laws and principles bearing upon the art of agriculture, and experiment, which has for its object the discovery of new applications of known laws and principles and better methods, both in the practice and business transactions of the farm and garden. The results of its investigations must of course be published and disseminated. In addition, this experiment station is charged with the execution of important control laws, — those relating to the manufacture and sale of commercial fertilizers and commercial feedstuffs, and the dairy law.

The cost of the work connected with the execution of these laws is covered by funds especially provided therefor. It makes no draft upon the funds appropriated for investigation, and the work is in the hands of a special staff which would not otherwise be employed. This work, therefore, does not lessen station capacity for investigation and experiment. On the other hand, as has been pointed out under the topic "Maintenance," since unexpended balances are available for certain kinds of experiment, our resources for investigation are somewhat increased because of the fact that the station is charged with the execution of these laws.

There are, however, constant and insistent requests for services which lie outside of the fields which have been designated, many of which are more or less private in character. To meet these requests would consume a large share of the time and energy of the members of our staff, and must greatly lessen their capacity for research. Not a few of these services are routine in nature, the same service is requested over and over again by different individuals, the results often have a transient value only, and it may be only to the individual requesting it. To use public funds for private work, especially in view of the fact that the public service must suffer if it is undertaken, would clearly be a mistake in policy.

Having thus endeavored to make the underlying principle and its reasonableness clear, a statement in detail of our attitude in relation to some of the kinds of service most frequently called for, with the special reasons therefor, seems desirable.

Chemical Analyses for Individuals. — Numerous requests for chemical analyses come to the station annually from individuals. There is hardly a substance of any possible interest to our citizens which we are not yearly asked to analyze. Soils, fertilizers, feeds, drinking waters, milk and cream, vinegar, drugs, minerals, and the viscera of animals supposed to have been poisoned are some of those most frequently sent in. Not a few individuals appear to regard such work as a proper function of the experiment station; occasionally one represents that as he is a taxpayer he has a right to such service, overlooking the fact that taxes are assessed to support public work, not to pay for private service. The majority, on having their attention called to the distinction referred to, take a correct view of the matter.

Many offer to pay the costs of analysis. The station is not organized for commercial work. Such work would almost inevitably interfere with more legitimate work, unless, indeed, a staff of chemists who should be employed in commercial work only should be maintained. This policy cannot at present be carried out. It would require separate laboratories, and it is not sufficiently constant to afford regular employment. Fortunately, there is little occasion for the establishment of a State laboratory for commercial work as there are numerous and reliable private commercial chemists. Further, there will be general agreement that for a State institution to engage in commercial work would be an unwise intrusion in a field where the rights of private enterprise would be infringed. The station, as a rule, does not (drinking waters excepted) accept compensation for any chemical analyses which it may undertake.

Analyses of Fertilizers or Feeds for Manufacturers or Dealers. — Under no circumstances can the station undertake chemical analysis as one of the necessary steps for manufacture or as a basis for guarantees. It should not and will not assume this responsibility.

Analyses of Fertilizers and Feeds for Consumers. — Not infrequently buyers send in samples, with the request that we determine the composition. It is contrary to sound policy, as a rule, to make such analyses, for two reasons: —

1. The materials in almost all cases are sampled in the course of the regular inspection and analyzed. A repetition is uncalled for.

2. It is not certain that these samples are properly taken, for to secure a thoroughly representative sample requires special instruction and experience. No suit nor claim for shortage can be based upon an analysis of a sample not officially taken.

In all cases, however, where either fertilizers or feeds are purchased on guarantee, with a definite understanding that the price shall be determined on the basis of analysis, the station is prepared to sample the goods where the transaction is of sufficient magnitude to warrant the expense, and will make the required analysis. Further, in the case of feeds it is sometimes possible, by mechanical separation and examination under low magnifying power (processes which can quite easily be carried out), to determine the ingredients, and such work the station will do on request.

Analyses of Soils. — The number of letters received asking for instruction in relation to sending samples of soil to be analyzed for the purpose of determining what fertilizers should be used, and the number of samples of soils sent in for such analysis for that purpose without previous inquiry, is constantly increasing. For this reason, although this matter is somewhat fully discussed in the twenty-first annual report, it seems necessary to refer to it again. There is widespread misapprehension as to the value of the chemical analysis of soils. It seems to be very generally believed: —

1. That chemical analysis will show to what crop a soil is suited.

2. That such analysis will determine what fertilizer should be applied and the quantities needed.

It seems also to be generally believed that the cause of crop disease will be revealed by a chemical analysis of the soil in which the crop is growing.

None of these views is justified by the facts. While the chemical condition of a soil is not altogether without influence in determining the crops to which it is suited, crop adaptation, at least within such range of soil variation as exists in this State, is determined in far greater degree by physical and drainage conditions. Neither does the chemical analysis of the soil show what fertilizers should be applied. Such analysis will determine with exactness the proportion of the several elements present, but it cannot show to what extent these elements are available; indeed, there is no such thing as a constant ratio of availability. The capacity of different crops to extract food from one and the same soil varies widely, and fertilizer requirements are determined in far greater degree by crop than by condition of the soil, within such limits of variation as are usually found in the soils of this State.

Occasionally a faulty chemical condition is responsible for an abnormal or unhealthy condition of the crop, but in most cases the immediately active cause of plant disease is the presence of a parasitic fungus, and this fungus is usually capable of fixing itself upon the plant, whatever may be the composition of the soil.

For the reasons briefly stated the chemical analysis of soils does not, as a rule, afford results which have a value commensurate with the cost, and this station will not, therefore, make such analysis unless a soil differs widely from the normal in natural characteristics, or has been subjected to unusual treatment of such a nature as to probably greatly influence its chemical condition.

In this connection attention is called to the fact that the most satisfactory means of determining the fertilizer requirements of crops is by carrying out a simple but carefully planned experiment in the field; and in all cases the station is glad to advise in relation to such experiments. It will furnish plans on application, provided the general conditions and the crops to be grown are indicated.

Water Analyses. — Properly taken samples of drinking water will be given a sanitary analysis, for which a uniform charge of $3 is made. This charge hardly equals cost. It is much below the usual figure for such work, which probably averages at least $10. A small charge was found to be necessary in order to prevent the indiscriminate forwarding of samples in such number as to constitute a serious burden, and in many cases when conditions hardly suggested any necessity for such analysis.

Analyses of Milk and Cream. — For the present, as has been our practice for some years, the station will analyze properly taken and preserved samples of milk and cream for fat and total solids, free of cost. This is done because facilities for such work are seldom within the reach of farmers, in order that it may be more fully recognized that the value of the product is not determined solely by the number of quarts or pounds of milk produced.

Foods and Drug Analyses. — This experiment station does not, under any conditions, undertake analyses of foods or drugs. It is not charged with the execution of the pure food law. That work in this State is looked after by the State Board of Health.

Personal Inspection of Farms or Lands. — Quite frequently a letter is received asking the station to send some one for the purpose of looking over a farm and advising in relation to its value or management, or for the examination of a certain tract of land, perhaps with reference to the possibility of its improvement, or for the purpose of determining what crops it is suited to. The station organization does not at present include men whose time is free for work of this description. Such work, moreover, is private in its nature; it is in the interest of individuals and not in the interest of the public; and it is doubtful whether, therefore, it is a proper function of the experiment station. Special trips for the examination of farms or tracts of land will not, therefore, be undertaken. We do constantly advise in relation to farm problems which are clearly and definitely brought before us, and members of the station staff make many visits to farms, orchards, gardens and hothouses for the study of important problems when the solution is likely to be of public as well as of private interest.

Station Literature. — It appears to be generally thought that the station is prepared to furnish comprehensive manuals on all subjects related to rural life. We constantly receive requests which begin: "Please send me your book, or your treatise, on ," and such subjects as potatoes, corn, strawberries, asparagus, cranberry culture, soils, drainage, etc. follow. The preparation of such manuals involves compilation rather than investigation. It is the latter for which the station is maintained. If distribution of such manuals is a proper function of any branch of an agricultural college it is that of the extension department rather than of the station. The station is not a publishing house. It is true that in connection with the report of the results of investigations it sometimes seems best to outline existing conditions, practices and opinions. In so far as this assists in correlating new results with earlier practice it is legitimate in a station publication, and some of our publications, therefore, may be valuable as a fairly comprehensive general guide to practice, but funds placed at the disposal of the station for investigation should not be, and are not, used for the preparation of exhaustive manuals.

CONTROL WORK.

No change has been made in either of the control laws with the execution of which the experiment station is charged. The regular inspections of fertilizers, feeds and dairy apparatus have been carried out without incidents requiring special mention. The amount of this work steadily increases, especially in connection with fertilizers and feeds, with the multiplication of brands. The comparative number of official samples for the past few years clearly shows this growth.

Number of Official Samples.

Year.	Fertilizers.		Feeds.	
	Brands.	Samples.	Brands.	Samples.
1909,	458	1,052	196	895
1910,	487	890	195	946
1911,	519	1,063	204	1,055
1912,	527	1,180	194	902
1913,	571	1,299	227	1,115

The table shows the number of brands of complete fertilizers and agricultural chemicals sampled in the State during each of the years since 1909. In that year the total number was 458; in 1913 it had grown to 571. In the latter year the number of brands of potato fertilizers offered for sale in the State was no less than 90. It is not easy to say, since registration has only recently been required, how many kinds of feed mixtures are offered for sale in the State, but the number is clearly very large. This matter is referred to for the reason that there can be no question that the continued multiplication of brands of fertilizers and feed mixtures increases the cost to the consumer, who in the last analysis must pay the costs of advertising, agencies, analyses, etc. The greater the number of kinds the greater these costs, and therefore, unless the kinds so differ from each other that each fills some special need or requirement which no other could fill equally well, this constant multiplication of kinds is to be deprecated. There are without doubt many more kinds, both of fertilizers and feeds, offered in our markets than are needed. No one will attempt to maintain for a moment that we need ninety kinds of potato fertilizers, nor is it possible that we need nearly six hundred different brands of fertilizers or over two hundred kinds of feeds. A reduction in the number would be a distinct advantage, both to manufacturers and dealers on the one hand and to consumers on the other.

Detailed reports on the control work will be found in the report of the chemist, Dr. J. B. Lindsey.

LINES OF WORK.

The lines of experiment and research followed for the past few years, and referred to in recent reports, have been continued. One new research problem has been taken up. This is in the poultry department. Provision for a breeding house was made by legislative appropriation in 1912, and with the coming of Dr. Goodale in February a study of some of the more important problems connected with the inheritance of such charcteristics as fertility, hatchability and fecundity was begun.

Another new line of inquiry has been undertaken during the year. This was made possible only by the rental of land for the purpose. The work in view is to determine by most careful experiment the rate of availability of the phosphoric acid of basic slag meal. The experiment is part of a plan recommended by the committee appointed by the Association of Official Agricultural Chemists. Thirteen other experiment stations are co-operating. This work is in direct charge of our fertilizer chemist, H. D. Haskins.

General Experiments.

An idea of the general work may be gained from the following enumeration of the principal lines of inquiry. These are: —

Soil tests with fertilizers with different crops in rotation; comparison of different materials available as sources, respectively, of nitrogen, phosphoric acid and potash for both field and garden crops, with a view to determining the ultimate effects of each on soil chemistry, biology and physics; results of the use of different forms of lime; systems of fertilizing mowings and orchards; trial of different manures and fertilizers for both tree and bush fruits; methods of applying manures;

variety tests of garden and field crops and of fruits; tests of different spray materials; comparison of methods of pruning; comparison of cover crops in orchard management; tests of southern *versus* northern nursery stock; of one and two year old apple trees; tests of trees pruned and not pruned at setting time; trials of new crops; determinations of the digestibility of feedstuffs; methods of feeding for milk; systems of feeding and management of poultry for eggs; tests of the efficacy of anti-hog cholera serum; studies upon the diagnosis and transmission of avian tuberculosis; co-operation with selected farmers in the trial of crops and systems of fertilizing them.

We have two substations, one for investigations connected with asparagus at Concord, the other for cranberry investigations in Wareham. Brief references to the work at these stations will be found later in this report.

Research.

The research problems under investigation are for the most part supported by the Adams fund, and have received the approval of the Office of Experiment Stations. The principal problems at present under investigation are the following: —

1. To determine the principles which should underlie practice in the use of fertilizers for the cranberry crop.

2. To determine the principles which should underlie practice in the use of fertilizers for asparagus.

3. Work in plant breeding in the endeavor to produce more rust-resistant types of asparagus. (In co-operation with the Bureau of Plant Industry, United States Department of Agriculture.)

4. Investigation of the solubility effect of ammonium sulfate on the soil of one of our experimental fields (Field A).

5. The effect of food on the composition of milk and butter fat and on the consistency or body of butter.

6. The cause of the digestion depression produced by molasses.

7. Why insecticides burn foliage.

8. Effects of meteorological conditions on the development of plants and crops, both in health and disease.

9. Influence of soil moisture on seed germination.

10. Relation of light to burning from spraying with fungicides and insecticides.

11. Nature and cause of burning from fumigation with various gases.

12. Effects of electricity on nitrogen fixation in soils and in stimulating plants in general.

13. Relation of light to burning of vegetation from miscible oils.

14. Study of interrelation of stock and scion in apples.

15. Plant breeding, especially with peas, beans and squashes, to determine the extent to which the Mendelian laws appear to govern heredity.

16. The relation of climate to variation in leading varieties of apples.

17. The economic importance of digger wasps in relation to agriculture.

18. Color vision in bees.

19. The diagnosis of white diarrhœa in adult fowls.

THE ASPARAGUS SUBSTATION, CONCORD.

The year 1913 at the Asparagus Substation in Concord was highly successful from the experimental point of view. Mr. Prescott continued his effective service in general local charge, and Mr. J. B. Norton of the United States Department of Agriculture, his enthusiastic breeding work. It will be remembered that the experiments at this substation are in two distinct lines: a study of the plant-food requirements of the crop and, second, breeding experiments with a view to the production of a rust-resistant type.

Plant-food Requirements.

The crop on the plots where the fertilizer experiments are located was the best produced in their history. The average yield per plot in 1912 was 278.5 pounds; in 1913 it was 374.9 pounds. The rate of yield per acre in 1912, 5,570 pounds; in 1913, 7,498 pounds. The average yield per plot in 1913 was, therefore, about 100 pounds greater than in 1912; the rate per acre in round numbers, one ton greater in 1913 than in 1912. The larger yields in 1913 were doubtless due in considerable measure to the fact that there was but little rust in 1912. It is thought that the specific effects of the different fertilizer elements and combinations, therefore, are shown much more clearly in the yields obtained in 1913 than in any previous year. It is not the purpose at this time to report either the plan of the experiment or the results in detail; but the following general conclusions appear to be warranted:

A fairly liberal use of chemical fertilizers is as effective to date in increasing yield as a combination of manure and fertilizers.

Effect of Nitrate of Soda as a Source of Nitrogen. Nitrate in Connection with Mineral Fertilizers (Acid Phosphate and Muriate of Potash). — Nitrate of soda greatly increases the crop, but a quantity in excess of the rate of 300 pounds per acre has not so far seemed to be beneficial, and in a considerable number of instances the minimum application (at the rate of 200 pounds per acre) has given a crop as good or even slightly better than any larger amount.

Season of Application of Nitrate. — Nitrate of soda in these experiments is applied in equal amounts in three different methods as regards season: —

(*a*) All in the early spring.

(*b*) Half in the early spring and half after the cutting season is ended.

(*c*) All after the cutting season is ended.

The results indicate a moderate degree of superiority for a method of application in which a portion at least of the nitrate is applied after the cutting season. This superiority shows itself both in slightly larger yield and in apparently making the crop somewhat more resistant to rust.

Nitrate in Connection with Manure. — In the case of all plots top-dressed with manure at the rate of 20,000 pounds to the acre the application of nitrate also has resulted in a distinct gain in yield, which, however, reaches its maximum on the medium quantity of nitrate (300 pounds per acre).

When nitrate is used in connection with manure (as in the other combinations referred to) summer application or divided spring and summer application gives results rather better than spring application.

Complete Chemical Fertilizers in Connection with Manure. — A mixture of chemicals, making what may be called a complete fertilizer (nitrate of soda, acid phosphate and muriate of potash), used in connection with manure at the rate of 20,000 pounds per acre, produced a moderate increase in crop, but the increase produced has not been as great as that produced by the use of nitrate alone in connection with the same amount of manure. The fact that the increase on the complete fertilizer is less than that produced by nitrate alone is probably not significant; but since it is no greater, the conclusion is apparently justified that the use of the acid phosphate and muriate of potash in connection with manure has not been beneficial.

Effect of Acid Phosphate. — The addition of acid phosphate to a combination of nitrate of soda and muriate of potash, furnishing adequate quantities of nitrogen and potash, has but little effect upon the crop.

Effect of Potash. — The use of muriate of potash in connection with a mixture composed of nitrate of soda and acid phosphate in adequate amounts greatly increases the crop, but a quantity in excess of 300 pounds to the acre has not been beneficial.

Comparison of Different Materials as a Source of Potash. — Muriate of potash is used in these experiments as the source of potash on almost all plots, but for the purpose of comparison one plot for each is introduced where the source of potash is different. The materials under comparison are wood ashes, kainit, high-grade sulfate of potash and low-grade sulfate of potash (potash-magnesia sulfate). The yield on all of these materials is considerably less than on the muriate of potash, but the kainit is considerably superior to the ashes or either of the sulfates. It is important, however, to call attention to the fact that it seems likely that the yield on the plots receiving ashes and the sulfates of potash is slightly decreased by the neighborhood of an oak tree, which stands about two rods distant from one end of the field.

General Conclusion. — The general conclusion is at least strongly suggested that in common practice among the asparagus growers of the State chemicals are frequently used in quantities in excess of those which are required to produce maximum crops.

Breeding Experiments.

The new types of asparagus produced by the crosses made by Professor Norton, and referred to in previous reports, have not been subjected to tests as severe as Professor Norton has desired during the past two years since rust has been less prevalent than usual. So far as can be judged, however, the best rust-resistant types fully retain their valuable characteristics. Numerous other crosses which are promising have been made.

We have experienced great difficulty in our efforts to produce seed from the more desirable breedings, owing to the ravages of the asparagus beetle (*Crioceris 12-punctata*), which preys both on foliage and directly upon the berries. Thus far no thoroughly satisfactory method of protection has been discovered. This fact will necessarily make the time when we shall be ready to distribute seed for trial later than we had hoped, and we are unable at present to announce when such distribution will be possible, nor can we state the basis on which any distribution will be made. Clearly, however, the new types must be so handled as to insure the multiplication of those which seem most desirable as rapidly as possible in order that they may be available at an early day for test under a wide diversity of conditions.

CRANBERRY SUBSTATION, WAREHAM.

A full report on the experimental work of the past year will be found in Bulletin 150 (Part II., page 37), which is a part of this annual report. Bulletin 150 also contains a paper by Professor Morse on the composition of bog waters (Part II., page 62).

The bog produced a very superior crop in 1913, both as to quantity and quality of the fruit. The accounts are so kept as to make it possible to distinguish between such expenses as would be required in ordinary bog management and such as are incurred in connection with the experiments in progress. The area of the bog is, in round numbers, twelve and one-half acres. The two financial statements follow: —

Bog Account.

Maintenance: —		
Tools and similar equipment bought or repaired,	$94 29	
Oil for engines, etc. (gasoline, kerosene and lubricating),	96 09	
Engine and bog pump repairs,	173 95	
Pumping labor,	84 10	
Bees, rental of,	6 00	
Mowing of upland,	57 35	
Weeding,	26 50	
Fertilizers,	49 20	
Mending dikes,	3 50	
Digging out ditches,	14 00	
Repairs to buildings,	1 95	
Lumber,	7 96	
Sundries,	27 10	
Miscellaneous labor,	50 15	
Raking vines after picking,	31 72	
		$723 86
Harvesting: —		
Picking,	$500 46	
Separating,	131 69	
Screening,	119 08	
Packing,	45 75	
Carting,	132 65	
Packing materials (barrels and coopering),	538 75	
		1,468 38
Contingent expenses,		3 38
Improvements: —		
Building roads,		42 40
Total,		$2,238 02

Experimental Account.

Experimental: —		
Labor,	$422 42	
Supplies and apparatus,	279 23	
Spraying materials,	10 10	
Fertilizers,	9 37	
		$721 12
Stationery and postage,		43 95
Traveling,		35 22
Contingent: —		
Freight,	$8 02	
Express,	7 15	
Surveying,	5 00	
Carting,	14 40	
Telephone,	27 11	
Painting,	9 50	
Lumber,	18 75	
Incidentals,	1 92	
Carpentering,	4 12	
		95 97
Furnishings,		1 25
Total,		$897 51

The total sales for the year were as follows: —

Fruit,	$6,667 22
Vines,	19 65
	$6,686 87

The total receipts for products sold amounted to $6,686.87. The total ordinary bog expenses were $2,238.02. Receipts for products sold, therefore, exceeded ordinary expenses to the amount of $4,448.85. It will be seen that the bog during the year has furnished a large surplus, available to help cover the costs of experimental work. The total experimental expenses shown in the above table amount to a little less than $900, but this, it should be pointed out, does not include the salary of the superintendent. Even with this included the bog during the past year is somewhat more than self-supporting, but attention is here called to the fact that cranberry bogs show a marked tendency to heavy fruit production in alternate years only. The product of 1912 sold for $1,069.87. If the two years, 1912 and 1913, then be included, the bog does not produce sufficient income to cover both ordinary and experimental expenses, and it can hardly be anticipated that over a series of years it will do this, although undoubtedly it will carry a considerable share of such expenses unless the scope of our work be greatly increased, as compared with that at present carried on.

During the past year Dr. Franklin has continued to co-operate with the United States Weather Bureau at Boston in weather observations, with a view to collecting data which shall be useful in forecasting frosts. He believes that substantial improvement has been made. At the same time important experiments on methods for frost protection have been in progress. The Skinner system of sprinkling has been tested, with unfavorable results. Other methods are suggested, among them protection from the early morning sun by smoke or some other screen, which method, however, has not been fully tested.

The value of keeping a bog well sanded as a means of frost protection is pointed out.

Co-operative work with the United States Department of Agriculture, which is represented in such work by Dr. Shear, has been continued. The results do not clearly indicate that the systems of spraying which were tried were efficacious.

Copper sulfate in different proportions in the flowage water has been tested as a fungicide. The results were not favorable.

Preliminary work looking toward the possible development of varieties superior to those now generally cultivated has been begun, — a line of work which should prove of much value.

The relation of insects, especially the honey bee, to the pollination of the flowers has been further studied, the results fully confirming those previously obtained. The cranberry appears to be dependent upon transfer of pollen by insects, and the honey bee is undoubtedly one of the most important among such insects.

Fertilizer experiments were continued, the application of materials being deferred until July 15, with a view to avoiding the possible loss through reflowage, which it was believed might be necessary up to that date for protection from insects or frosts. There was no increase in crop as a result of the application of any of the fertilizers; indeed, the fertilized plots gave somewhat smaller yields than the unfertilized. Whether this was due to the lateness of the application is uncertain. The result is, however, the opposite to that which was obtained in 1912.

A large part of the work of Dr. Franklin has consisted in further study of the various insects which affect the crop. The observations made and the results obtained are fully set forth in Dr. Franklin's report. Among the more important conclusions which appear to be justified are the following: —

Careful observations have been made on a span worm (*Epelis truncataria* var. *faxonii* Minot). The pupæ are not destroyed by winter flowage. Heavy sanding kills most of them. In cases of very heavy infestation burning over the bog may be the best course to take in order to get rid of the insect.

Observations and further experiments on the flowed bog fireworm (*Rhopobota vacciniana* (Pack.)) indicate that late holding of the winter flowage (until about June 1), and reflowing about three weeks later, is an effective means of destroying this insect. Spraying with arsenates is also useful, but whether arsenate of lead or Paris green should be preferred is not yet certain, although it is believed that the arsenate of lead is the better of the two. There appears to be a considerable difference in the extent to which different varieties are attacked by this insect, the Late Howe being much more seriously injured than the Early Black.

A number of important parasites of the fruit worm (*Mineola vaccinii* (Riley)) have been discovered and studied. The most important among them appears to be *Phanerotoma tibialis.* Just how important this will prove to be in helping to control the fruit worm is not yet clear. Observations indicate that parasites are much more abundant on dry bogs than on those which are flowed.

Flowage experiments indicate that fall flowage, whatever the depth, is not effective in destroying the fruit worm. Experiments on dry bogs indicate that resanding is not an effective method, and the suggestion is made that in case of very heavy infestation the destruction of all the bloom by spraying with a solution of iron sulfate will be an effective means of starving out this insect in a bog so treated.

Experiments on weed destruction by spraying with iron sulfate indicate that a 20 per cent. solution is fairly effective in killing the tops of horsetail (*Equisetum*), but the roots were not killed; and Dr. Franklin is not ready to recommend repeated use of such a solution, as it is possible that in large amounts it will prove injurious to the cranberry itself.

Copper sulfate dissolved at the rate of 1 pound to 25 gallons of water injected into holes in the bogs proves ineffective.

Careful observations upon the fruit produced by plots respectively untreated and resanded indicated that resanding injures keeping quality.

Professor Morse's work in the study of the water from cranberry bogs indicates that the composition of this water was not affected to an appreciable extent by the varying fertilizer treatment of the different bogs. His observations further indicate that vine growth is affected in greater degree by varying drainage conditions than by variation in fertilizer applied. The greatest vine growth was obtained in the bogs through which the water moved with greatest freedom.

INVESTIGATION.

In the agricultural department of the experiment station the lines of experimental work pursued have been similar to those followed for the last few years, but supplemented more and more fully by correlated chemical studies. In this work the usual number of field and closed plots has been employed. The number of pot experiments has been less than usual, owing to the absence of the director during the early part of the year. Attention will be here called to a few only of the results which seem most fully established.

High-grade sulfate of potash combined with bone meal continues to show itself superior to muriate in the same combination for alfalfa, raspberries, blackberries and rhubarb. The rates of yield per acre for these crops on the two potash salts under comparison during 1913 were as follows: —

	Muriate of Potash.	Sulfate of Potash.
Rhubarb (pounds),	17,913	24,174
Blackberries (pounds),	6,162	8,263
Raspberries (pounds),	2,068	2,683
Alfalfa (tons),	3.7	4.2

Muriate of potash, on the other hand, gives much larger yields of asparagus than the sulfate, both being used with equal quantities of bone meal. The rates of yield per acre are as follows: —

	Muriate of Potash.	Sulfate of Potash.
Asparagus (pounds),	6,927	6,007

The combination of low-grade sulfate of potash with bone meal continues to give larger yields of apples than muriate in such quantities as to furnish equal potash in the same combination. The yield of apples under the different fertilizer treatments in the season of 1913, and the total yields to date, are shown in the following table: —

Yield of Apples (Pounds).

	Plot 1, Manure.	Plot 2, Ashes.	Plot 3, Nothing.	Plot 4, Muriate of Potash and Bone.	Plot 5, Sulfate of Potash and Bone.
1913,	7,977	4,954.5	3,032	6,233	7,992
Totals to date,	41,547	25,226.0	10,148	23,360	34,663

As in previous years the three Gravenstein trees in the sulfate of potash plot gave a smaller yield in 1913 than the three Gravenstein trees in the muriate of potash plot, a result perhaps due to the proximity of the trees in the sulfate of potash plot to a neighboring forest.

Some fire blight showed itself in this orchard during the past season. The several plots in severity of blight injury ranked in the following order: 4, 5, 1, 2, 3. The Greening variety showed more blight than any other in all the plots except No. 5, in which the Gravenstein showed rather more than the Greening.

In the south soil test, where each plot has been continuously fertilized in the same way for twenty-five years, the crop in 1913 being corn, muriate of potash showed itself to be much superior to either nitrate of soda or acid phosphate in its effect upon that crop. The average rates of yield per acre on the nothing plots were: —

	Hard Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
Nothing plots,	2.2	7.9	1,870

The rates of yield on the different fertilizer combinations were as follows: —

	Hard Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
Nitrate of soda alone,	7.7	14.9	2,420
Dissolved boneblack alone,	1.3	9.7	2,180
Muriate of potash alone,	44.9	7.7	4,360
Nitrate of soda and muriate of potash,	46.9	4.3	3,500
Dissolved boneblack and muriate of potash,	44.6	5.1	4,040
Nitrate of soda, dissolved boneblack and muriate of potash,	40.0	4.4	3,840

It will be noted that only where potash is used is there any considerable increase in the crop.

In the north corn acre the fertilizer combination richer in potash gives a rather higher yield of hay than the combination relatively low in potash and high in phosphoric acid, which is similar in composition to the average of the corn fertilizers offered in our markets. This is the twenty-third year of this experiment.

On the south corn acre manure alone at the rate of 6 cords per acre gives about 600 pounds more hay than the combination of 4 cords of manure and 160 pounds of high-grade sulfate of potash. This is the twenty-fourth year of this experiment.

In the experiment comparing different phosphates used in such quantities as to furnish equal phosphoric acid, which has been in progress since 1897, the crop this year was corn. The apparent effects of the different phosphates upon the crop are shown in the following table: —

	Gain or Loss.	
	Corn (Bushels).	Stover (Pounds).
Plot 1, no phosphate,	-	-
Plot 2, Arkansas rock phosphate,	—1.9	+240
Plot 3, South Carolina rock phosphate,	—2.2	+720
Plot 4, Florida soft phosphate,	—0.2	+720
Plot 5, basic slag meal,	+6.1	+736
Plot 6, Tennessee rock phosphate,	+1.9	+720
Plot 7, no phosphate,	-	-
Plot 8, dissolved boneblack,	+3.5	+720
Plot 9, raw bone,	+7.3	+1,160
Plot 10, dissolved bone meal,	+14.3	+920
Plot 11, steamed bone,	+15.2	+1,240
Plot 12, acid phosphate,	+10.6	+1,320
Plot 13, no phosphate,	-	-

It will be noted that the effect of the untreated rock phosphates upon the yield of grain is extremely small, there being in most cases a slight decrease. On the other hand, the bone meal, both raw and steamed, the basic slag and the superphosphates (dissolved boneblack, dissolved bone meal and acid phosphate) all give moderate increases. There is an increase in stover in all cases, but materially smaller on the untreated rock phosphates than on most of the others.

The crop of grain was undoubtedly smaller than it otherwise would have been because of the effects of the heavy frost which came just before the middle of September, at which time the ears were not mature. This frost killed the leaves of the plants and the outer husks of the ears, but did not entirely check their development. There was, however, a large proportion of soft corn. The proportion of soft corn on the basic slag meal was least, and in general less on the soluble than on the more insoluble phosphates. The effect of the fertilizer, however, is undoubtedly somewhat obscured by the fact that there is a gradual increase in the proportion of clay in the soil from plot 1 toward plot 13. This difference makes the soil colder at the end of the field, where the more soluble phosphates were used, than at the other end, and this condition undoubtedly tended to increase the proportion of immature corn.

The percentage of soft or immature corn as compared with sound corn on the several plots is shown below: —

Percentage of Soft Corn as compared with Sound.

Plot 1, no phosphate,	48
Plot 2, Arkansas rock phosphate,	66
Plot 3, South Carolina rock phosphate,	87
Plot 4, Florida soft phosphate,	48
Plot 5, basic slag meal,	30
Plot 6, Tennessee rock phosphate,	51
Plot 7, no phosphate,	84
Plot 8, dissolved boneblack,	86
Plot 9, raw bone,	58
Plot 10, dissolved bone meal,	44
Plot 11, steamed bone,	52
Plot 12, acid phosphate,	67
Plot 13, no phosphate,	80

In the experiment in top-dressing mowings with different materials used in rotation since 1895 the crop was much below the average on account of the great deficiency in rainfall, especially during the latter part of the season. The rates per acre were as follows: —

	Hay (Pounds).	Rowen (Pounds).
Plot 1, bone and potash,	4,117	963
Plot 2, slag and potash (in place of ashes used in earlier years),	3,604	710
Plot 3, manure,	3,522	720

In this field two different seed mixtures, referred to in previous reports respectively as the "fescue mixture" and the "timothy mixture," are under comparison. The "fescue mixture," as has been true for the past few years, gave a considerably larger crop than the "timothy mixture."

The chemical department during the past year has published one bulletin, "The Record of the Station Herd and the Cost of Milk Production." This shows that the larger cows produce milk at lower cost than the smaller, and the conclusion drawn from the records (which are exact as regards food consumed and milk yield, but necessarily estimated as regards labor and some other items) is that milk of satisfactory quality can probably not be produced and sold at the farm at a profit at less than from 5 to 5½ cents per quart.

The chemical department has published a bulletin, "The Digestibility of Cattle Foods," found later in this report. In this will be found the results obtained in a large number of digestion experiments.

The chemical department has continued the study of the effects of food on the composition of milk. In this connection it has been found necessary, for accurate determination of the chemical composition of butter fats, to discover and perfect new methods and apparatus. A bulletin, "The Determination of the Acetyl Number," found later in this report, describes one of the improved methods. Some new forms of apparatus and other methods now under trial are highly promising and will be described in later papers.

The study of the composition of asparagus shoots and tops at successive stages of growth has been continued in connection with our study of the nutrition of this plant. Up to the present time no clear relation between fertilizer treatment and composition has been proved.

Cranberry nutrition studies have been continued, the composition of the waters of the small artificial bogs established at the station receiving particular attention. A paper on this subject will be found in a bulletin in later pages, "Reports on Experimental Work in Connection with Cranberries."

In the continued study of the effects of sulfate of ammonia on the soil it has been found that its use as a fertilizer seems to cause a large removal of calcium in the drainage waters, and it seems probable that the so-called acidity of soils fertilized with this substance is due, in part at least, to the solvent action of the ammonium sulfate on the calcium.

It has been shown in the feeding experiments carried on in this department that fish meal may be used as a source of a part of the protein in the ration for dairy cows, although, owing to the cost of such meal, it is doubtful if this would be the most profitable practice.

Extensive experiments with Molassine meal have shown that at usual relative prices it is not an economical food for cows.

The report of the chemist, found in later pages, discusses these matters in greater detail. In this report will be found also a fuller statement than that found earlier in this report of the work of the fertilizer, feed and dairy sections of the department, as well as a brief account of its general analytical and other work.

The botanical department has published a bulletin, "The Relation of Light to Greenhouse Culture." This presents the results of numerous experiments, which clearly show the close relation of varying light conditions to the development and health of crops. Upon these results are based important recommendations as to the location and construction of greenhouses.

The principal line of investigation followed in the department for several years — the effects of environment upon the growth of plants and crops, both in health and disease — has been continued.

A new form of spray nozzle, which is unusually efficient at a considerable distance from the point of discharge, has been perfected and patented.

Another subject which is receiving careful investigation is the relation of light to burning, following application of miscible oils.

The report of the botanist, found in later pages, discusses the matters here referred to in greater detail.

The investigation work in the poultry department has been well started. The principal line of work in progress is a thorough study of the capacity of each hen in a carefully selected breeding flock of 144 birds to produce: (*a*) eggs, (*b*) fertile eggs, (*c*) hatchable eggs, (*d*) viable chicks, (*e*) vigorous adults; and of the ability of each hen to transmit these qualities to her progeny.

In the department of pomology a bulletin, — "A Study of Variation in Apples," — found later in this report, has been issued. This bulletin presents the conclusions based on a study of climatic and other conditions upon the size, shape and other characteristics of apples. The investigation shows in general that a high temperature is favorable to the development of relatively flattened forms, and that, on the other hand, a low temperature, especially during a period immediately following the setting of the fruit, is favorable to elongated forms.

In the veterinary department methods of diagnosing infection with the bacterium which causes white diarrhœa in the chicks of the domestic fowl have been studied, and a bulletin on the subject — "On the Diagnosis of Infection with Bacterium Pullorum in the Domestic Fowl" — is found later in this report. The conclusion is that the examination of the eggs from suspected hens is not a practicable method for rapid diagnosis. On the other hand, macroscopic agglutination tests of the blood can be rapidly made and appear to give reliable indications.

In the entomological department the life history of the marguerite leaf miner (*Phytomyza chrysanthemi* Kow.) has been worked out and methods for its control discovered. Numerous insecticides have been tested. A very active and efficient parasite of the San José scale has been discovered. The work of this parasite has been found very effective, having resulted in the destruction of over 90 per cent. of the scales on the branches of trees examined in many cases. The entomologist has supplied parasitized scale to stations in a number of other States and is still supplying material on request. A fuller report concerning this scale and other work of the entomological department will be found in later pages.

The report of the treasurer immediately follows the director's report.

WM. P. BROOKS,

Director.

REPORT OF THE TREASURER.

ANNUAL REPORT

Of Fred C. Kenney, Treasurer of the Massachusetts Agricultural Experiment Station of the Massachusetts Agricultural College, for the Year ending June 30, 1913.

United States Appropriations, 1912–13.

	Hatch Fund.	Adams Fund.
Dr.		
To receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1913, under acts of Congress approved March 2, 1887 (Hatch fund), and March 16, 1906 (Adams fund),	$15,000 00	$15,000 00
Cr.		
By salaries,	$9,669 91	$12,583 58
labor,	2,319 19	931 46
publications,	386 23	–
postage and stationery,	108 45	21 16
freight and express,	6 25	14 31
heat, light, water and power,	20 76	110 94
chemicals and laboratory supplies,	99 68	514 26
seeds, plants and sundry supplies,	369 52	200 71
fertilizers,	726 47	88 05
feeding stuffs,	625 84	–
library,	118 08	22 03
tools, machinery and appliances,	204 77	5 29
furniture and fixtures,	36 25	9 00
scientific apparatus and specimens,	114 77	119 80
live stock,	6 40	–
traveling expenses,	131 13	76 61
contingent expenses,	–	–
buildings and land,	56 30	302 80
Total,	$15,000 00	$15,000 00

State Appropriation, 1912–13.

Cash balance brought forward from last fiscal year,	$6,787 28
Cash received from State Treasurer,	19,875 00
fertilizer fees,	10,444 99
farm products,	4,361 77
miscellaneous sources,	9,357 40
	$50,826 44

Cash paid for salaries,	$19,736 36
labor,	7,728 98
publications,	1,573 42
postage and stationery,	1,152 77
freight and express,	361 62
heat, light, water and power,	419 87
chemicals and laboratory supplies,	1,014 37
seeds, plants and sundry supplies,	1,104 18
fertilizers,	321 80
feeding stuffs,	893 68
library,	215 36
tools, machinery and appliances,	507 39
furniture and fixtures,	392 97
scientific apparatus and specimens,	104 40
live stock,	231 50
traveling expenses,	2,737 34
contingent expenses,	130 00
buildings and land,	625 88
balance,	11,574 55
	$50,826 44

REPORT OF THE CHEMIST.

JOSEPH B. LINDSEY.

1. Work of the Research Section.

Mr. Holland and assistant have devoted their time largely to a study of methods for a more thorough examination of butter fat in connection with our study of the effect of food upon the composition of milk. The work has been along the following lines: —

(*a*) The study of methods for the quantitative determination of the several insoluble fatty acids in butter fat. This has led to a very thorough study of the constitution of oils and fats, and resulted in a new process for the determination of hydroxy acids, both free and combined, of monoglycerides and diglycerides and of free insoluble alcohols. A paper on this subject will be published as a bulletin.

The study has led also to the development of a new process for the determination of stearic acid, which promises to be far preferable to that of Hehner and Mitchell on account of better thermostatic control during the filtration period.

The large amount of analytical work has, in itself, brought to light a mass of valuable information relative to solutions and details of manipulation which assure greater accuracy, and has resulted in a systematic correlation and standardization of the more common methods.

In addition to the above, butter fat from Jersey and Holstein cows at the beginning and end of lactation has been analyzed by recognized methods.

(*b*) The stability test with olive oil is being continued. While the physical changes are pronounced in many instances, the chemical are not sufficient as yet to merit a report.

(*c*) The work on insecticides has been comparatively light, and that largely advisory, with the exception of a careful examination of several samples of a new dry acid lead arsenate which the entomological department has tried the past season.

(*d*) Considerable time has been spent during the past year in the development of an adiabatic bomb calorimeter, in co-operation with Mr. E. A. Thompson, the able mechanic of Amherst. The apparatus is now completed and is proving quite satisfactory.

Mr. Morse and assistant have given their time to work on asparagus, cranberries, and to the action of sulfate of ammonia on the soil of field A of the station.

(*a*) The work of the past year on asparagus has been the completion of determinations of the composition of asparagus shoots and tops at successive stages of growth.

(*b*) The study of the composition of the drainage water of miniature cranberry bogs constructed on the station grounds has been continued on the same lines as last year, with still more attention to details of individual bogs.

(*c*) Effect of sulfate of ammonia on the soil. Particular attention has been given to composition of the drainage waters in field A and also to the ability of the soil in different plats of the field to absorb ammonia from the ammonium sulfate. One notes a large removal of calcium from the soils of the plats receiving ammonium sulfate. The so-called acidity of soils thus fertilized is probably due, in part at least, to the solvent action of the ammonium sulfate on the calcium.

Work in animal nutrition by Dr. Lindsey has included: —

(*a*) Digestion experiments with hay, corn meal, mangels, cabbage, cabbage leaves, Swedish turnips, Postum cereal residue, Mellin's Food waste, two kinds of fish meal and Molassine meal.

(*b*) A study of fish meal as a source of protein for dairy animals. A combination of bran, corn meal and cottonseed meal was compared with bran, corn meal and fish meal. The results indicated that it was perfectly feasible to use fish meal as a part of the ration for dairy animals; but at prices usually prevailing, it might make the ration a little more expensive.

(*c*) Molassine meal as an economic food for farm stock. The experiment indicated that, at the same moisture content, 1 ton of Molassine meal contained substantially 900 pounds of digestible organic matter, as against 1,400 pounds for corn meal. On this basis Molassine meal would have scarcely two-thirds of the nutritive value of the corn. An experiment with milch cows was made in which 4.3 pounds of corn meal were fed against 4.3 pounds of Molassine meal. The cows yielded some 14 per cent. more milk on the ration of which corn meal was a component.

(*d*) Studies have been continued on milk substitutes for dairy calves and the food cost of rearing dairy heifers until two years of age.

2. Work of the Fertilizer Section.

The principal work of the fertilizer section has been the annual inspection of commercial fertilizers. There has been a decided increase in the work of the fertilizer inspection from year to year. A larger number of commercial fertilizers has been registered, collected and analyzed during 1913 than for any previous year.

(*a*) *Fertilizers registered.*

One hundred manufacturers, importers and dealers, including the various branches of the large corporations, have secured certificates for the sale of fertilizer, agricultural chemicals, raw products and agricultural limes in the Massachusetts markets during the season of 1913. They may be classed, as follows: —

Complete fertilizers,	346
Fertilizers furnishing phosphoric acid and potash,	9
Ground bone, tankage and dry ground fish,	58
Chemicals and organic nitrogen compounds,	101
Agricultural limes,	27
	541

(*b*) *Fertilizers collected and analyzed.*

During the present season 133 towns were visited and 1,299 samples, representing 571 brands, were drawn from stock found in the possession of 381 different agents. This is 119 more samples, representing 44 more brands, than were taken during the previous year.

Seven hundred and forty-seven analyses (573 distinct brands) have been made during the year's inspection, as follows: —

Complete fertilizers,	427
Materials furnishing phosphoric acid and potash,	26
Ground bone, tankage and fish,	67
Nitrogen compounds,	95
Potash compounds,	45
Phosphoric acid compounds,	47
Lime compounds,	40
	747

The details regarding this inspection work will be found in Bulletin No. 147, published in December, 1913.

(*c*) *Other Work of the Fertilizer Section.*

Analyses were made of the ash of 4 samples of crimson clover plant and root, of 10 samples of asparagus plants and of 8 samples of tobacco leaves; 86 dry-matter determinations were also made on different field crops in connection with experimental work of this section.

In addition to the above, 326 different substances have been received from farmers, farmers' organizations and the various departments of the experiment station, and analyzed as follows: —

Fertilizers and by-products used as fertilizers,	149
Lime products,	19
Soils for lime requirement test.	68
Soils for complete analysis,	4
Dry-matter determinations,	86
	326

Considerable time has been given to co-operative work with the Association of Official Agricultural Chemists, Mr. L. S. Walker having served the association in the capacity of associate referee on phosphoric acid for the past season. In this work new methods for the analysis of basic slag phosphate have been studied, also new methods for the determination of available nitrogen and potash in fertilizers.

(*d*) *Field Experiments with Basic Slag Phosphate.*

This experiment was instituted at the request of the committee on basic slag, which was appointed by the Association of Official Agricultural Chemists for the purpose of determining, through vegetation tests, the efficiency of the phosphoric acid in basic slag phosphate.

In the fall of 1912, two acres of land, belonging to the Dillon farm, situated on the street leading from Amherst to Cushman, were leased for this experiment. It will be necessary, at first, to exhaust the soil of available phosphoric acid, which will require at least two years.

(*e*) *Field Experiments with New Mineral Fertilizer and Stone Meal.*

The field which served for this experiment was a part of the two-acre field leased from the Dillon farm and adjoining the land used for the basic slag experiment. The details of the experiment with each crop have been published in Fertilizer Bulletin No. 147.

(*f*) *Incompleted Work.*

A series of pot experiments was begun in the greenhouse during the fall and winter of 1912 to determine the efficiency of stone meal and the new mineral fertilizer as sources of plant food. At the present writing the dry-matter determinations have not been made on the crops grown, and the results will, therefore, be reserved for a future publication.

Many of the cotton mills in the eastern part of the State produce large quantities of a cotton waste product which shows, upon analysis, a considerable quantity of plant food in connection with a large amount of organic matter. An experiment was undertaken during the past season to show to what extent the product could be depended upon to take the place of manures and fertilizers. The results are not yet ready for publication.

3. Report of the Feed and Dairy Section.

(a) *The Feeding Stuffs Law (Acts and Resolves for 1912, Chapter 527).*

The first year's work with the revised feeding stuffs law was completed Sept. 1, 1913. There have been collected and examined, since the law went into effect, 1,115 samples, all of which practically conformed to their guarantees. The year has been considered one of adaptation to new conditions, and no prosecutions for violations of the law have been made, although where infringement of the statute was noted, attention was pointedly called to the matter through correspondence and conditions corrected. The text of the new law was published in Bulletin No. 142. Bulletin No. 146 gives the results of the inspection for 1913.

(b) *The Dairy Law (Acts and Resolves for 1912, Chapter 218).*

The dairy law, so called, requires that all milk inspectors and other operators who use the Babcock test as a means of determining the value of milk or cream shall secure a certificate of competency from the experiment station. It also provides that the glassware employed must be tested for accuracy by the experiment station and marked in such a way as to indicate the fact. In addition, an annual inspection of machines and apparatus in the various laboratories of the operators is required.

1. *Examination for Certificates.* — Twenty candidates were given certificates of proficiency during the year.

2. *Examination of Glassware.* — Six thousand three hundred and ninety-four pieces of Babcock glassware have been tested, of which only 34 pieces were condemned as inaccurate. The inspection shows an increasing number of 9-inch cream bottles

and of the 8 per cent. milk test bottles in use. They are more accurate than the 6-inch cream bottle and the 10 per cent. milk test bottle.

Following is a summary for the thirteen years the law has been in operation: —

Year.	Number of Pieces tested.	Number of Pieces condemned.	Percentage condemned.
1901,	5,041	291	5.77
1902,	2,344	56	2.40
1903,	2,240	57	2.54
1904,	2,026	200	9.87
1905,	1,665	197	11.83
1906,	2,457	763	31.05
1907,	3,082	204	6.62
1908,	2,713	33	1.22
1909,	4,071	43	1.06
1910,	4,047	41	1.01
1911,	4,466	12	.27
1912,	6,056	27	.45
1913,	6,394	34	.53
Totals,	46,602	1,958	4.20[1]

[1] Average.

3. *Inspection of Machinery and Apparatus.* — Mr. James T. Howard, as deputy inspector, has visited and inspected the Babcock machines and apparatus in 78 creameries, milk depots and milk inspectors' laboratories. Conditions were found much improved over those prevailing at the time of the previous inspection. In only one case was uninspected glassware found in use and but four machines were condemned. The use of the electrical tester is increasing rapidly. The larger number of the milk inspectors employ such a tester, as do also several of the milk depots. Most of the cities and larger towns are realizing the importance of safeguarding the milk supply and are giving their inspectors satisfactory equipment and well-furnished laboratories. Following is a list of creameries, milk depots and milk inspectors known to be using the Babcock test and visited by our inspector: —

1. *Creameries.*

Location.	Name.	Manager or Proprietor.
1. Amherst,	Amherst,	R. W. Pease, proprietor.
2. Amherst,	Fort River,[1]	E. A. King estate, proprietors.
3. Ashfield,	Ashfield Co-operative,	Wm. Hunter, manager.
4. Belchertown,	Belchertown Co-operative,	M. G. Ward, manager.
5. Brimfield,	Crystal Brook,	F. N. Lawrence, proprietor.
6. Cummington,	Cummington Co-operative,	D. C. Morey, manager.
7. Egremont,	Egremont Co-operative,	E. A. Tyrell, manager.
8. Easthampton,	Hampton Co-operative,	W. S. Wilcox, manager.
9. Heath,	Cold Spring,	F. E. Stetson, manager.
10. Hinsdale,	Hinsdale Creamery Company,	W. Solomon, proprietor.
11. Monterey,	Berkshire Hills,	F. A. Campbell, manager.
12. Northfield,	Northfield Co-operative,	John E. Nye, manager.
13. Shelburne,	Shelburne Co-operative,	I. R. Barnard, manager.
14. Wyben Springs,	Wyben Springs Co-operative,	C. H. Kelso, manager.

[1] Testing done at Massachusetts Agricultural Experiment Station.

2. *Milk Depots.*

Location.	Name.	Manager.
1. Boston,	Boston Condensed Milk Company,	R. Burns.
2. Boston,	Boston Jersey Creamery,	E. F. Luce.
3. Boston,	Elm Farm Milk Company,	J. H. Knapp.
4. Boston,	H. P. Hood & Sons,	C. H. Hood.
5. Boston,	Oak Grove Farm,	John Alden.
6. Boston,	Plymouth Creamery Company,	R. Gardner.
7. Boston,	Turner Center Dairying Association,	I. L. Smith.
8. Boston,	Walker-Gordon Laboratory,	G. Franklin.
9. Boston,	D. Whiting & Sons,	George Whiting.
10. Cambridge,	C. Brigham Company,	J. K. Whiting.
11. Cheshire,	Ormsby Farms,	E. B. Penniman.
12. Everett,	Hampden Creamery,	F. H. Adams.
13. Pittsfield,	H. H. Prentice & Co.,	H. H. Prentice.
14. Sheffield,	Willow Brook Dairy,	Frank Percy.
15. Southborough,	Deerfoot Farm,	C. H. Newton.
16. Springfield,	Tait Brothers,	H. Tait.
17. Worcester,	C. Brigham Company,	N. W. King.
18. West Stockbridge,	Borden Milk Company,	T. L. Roberts.

3. *Milk Inspectors.*

Location.	Inspector.	Location.	Inspector.
1. Adams,	A. G. Potter.	24. Newton,	Arthur Hudson.
2. Andover,	F. H. Stacey.	25. New Bedford,	H. B. Hamilton.
3. Arlington,	L. L. Pierce.	26. North Adams,	H. Tower.
4. Barnstable,	G. T. Mecarta.	27. Northampton,	G. R. Turner.
5. Boston,	J. O. Jordan.	28. Pittsfield,	E. L. Hannum.
6. Brockton,	G. G. Bolling.	29. Plainville,	John Eiden.
7. Cambridge,	W. A. Noonan.	30. Revere,	J. E. Lamb.
8. Chelsea,	W. S. Walkley.	31. South Hadley,	G. F. Boudreau.
9. Chicopee,	C. L. O'Brien.	32. Somerville,	H. E. Bowman.
10. Clinton,	G. L. Chase.	33. Springfield,	S. C. Downs.
11. Everett,	E. Clarence Colby.	34. Springfield,	Emerson Laboratory.[1]
12. Fall River,	H. Boisseau.	35. Taunton,	L. I. Tucker.
13. Fitchburg,	J. F. Bresnahan.	36. Wakefield,	H. A. Symonds.
14. Gardner,	C. W. Shippee.	37. Waltham,	A. L. Stone.
15. Greenfield,	G. P. Moore.	38. Ware,	F. E. Marsh.
16. Haverhill,	H. L. Conner.	39. Watertown,	L. C. Simmons.
17. Holyoke,	D. P. Hartnett.	40. Wellesley,	R. W. Hoyt.
18. Lawrence,	J. H. Tobin.	41. Westfield,	W. M. Porter.
19. Lowell,	M. Marster.	42. West Springfield,	N. T. Smith.
20. Lynn,	H. P. Bennett.	43. Winchendon,	G. W. Stanbridge.
21. Millbury,	F. A. Watkins.	44. Winchester,	Morris Dinneen.
22. Malden,	J. I. Sanford.	45. Woburn,	E. P. Kelley.
23. Medford,	Winslow Joyce.	46. Worcester,	G. L. Berg.

[1] Does work for the State Dairy Bureau.

(*c*) *Water Analysis.*

Ninety-three samples of water have been examined during the past year at the usual charge of $3 a sample. A large number of these, especially those samples taken from wells, have been condemned as unfit for domestic use. Public water supplies are supervised by the State Board of Health.

(*d*) *Milk, Cream and Feeds for Free Examination.*

Many samples of milk, cream and feeding stuffs are received each year at the laboratory for free examination. In general, it is preferred that application be made for sampling and shipping instructions before the sample is submitted. Only samples of direct agricultural interest are considered, and the experiment station will not act in the capacity of a private chemist for a feed manufacturer, milk depot or creamery.

(*e*) *Miscellaneous Work.*

In addition to the work already described, this section has co-operated with other departments of the college and State, as follows: —

1. It has arranged exhibits and furnished speakers in co-operation with the extension service for fairs, farmers' meetings and expositions.

2. It has co-operated with the Bowker Fertilizer Company in making starch determinations on potatoes in connection with the awarding of prizes.

3. It has co-operated with the agricultural department of the college in making analyses of milk in connection with the awarding of prizes at a dairy show held during "farmers' week."

4. It has co-operated with the agricultural department of the experiment station in making analyses of the corn plant to determine the effect of frosts upon the nutritive value of the plant.

5. It has assisted the horticultural department of the college by analyzing root crops to determine the effect of cold storage in modifying their chemical character.

(*f*) *Testing of Pure-bred Cows for Advanced Registry.*

During the year, ten different men have been used for the Holstein-Friesian work, and the entire time of three other men has been taken in conducting the work for the Guernsey, Jersey, Ayrshire and Brown Swiss associations. From Dec. 1, 1912, to Dec. 1, 1913, 86 Guernsey, 122 Jersey, 2 Brown Swiss, 18 Ayrshire and 4 Holstein yearly tests have been completed. There are now on test 110 Jerseys, 111 Guernseys, 24 Ayrshires and 1 Brown Swiss, located at 28 different farms. For the Holstein-Friesian Association there have been completed 120 seven-day tests, 10 thirty-day tests, 5 fourteen-day tests and 1 sixty-day test.

4. Numerical Summary of Substances examined in the Chemical Laboratory.

The following substances have been received and examined: 93 samples of water, 305 milk, 1,452 cream, 3 ice cream, 2 butter, 191 feedstuffs, 149 fertilizers and fertilizer refuse materials, 72 soils, 19 lime products, 22 plant ash and 6 miscellaneous. There have also been examined in connection with experiments in progress by the several departments of the station, 167 samples of milk and cream, 193 cattle feeds and 352 agricultural plants. In connection with the control work, there have been collected 1,299 samples of fertilizer and 1,115 samples of feedstuffs. In addition, 30 samples of coal have been analyzed by the research section for the college heating plant. The total for the year was 5,470. This does not include the work of the research section, where many analyses are made in connection with research problems, nor the work under the dairy law already reported.

5. Correspondence.

The number of letters sent out during the year is about 5,000. The larger part of the correspondence is devoted to work in connection with our several inspection laws. A considerable amount of time, however, is devoted to the answering of special inquiries from the farmers of this State.

REPORT OF THE BOTANIST.

GEO. E. STONE.

During the past year the work in this department has been along the usual lines, attention being given to new problems as they arise. The drought was so severe that an unprecedented number of urgent calls for investigation of diseases had to be attended to, and the diagnosis work taxed our resources severely.

The usual seed work, consisting of separation and tests for germination and purity, has been carried on, but the equipment is deficient, especially for germination work.

Mr. G. H. Chapman, research assistant, has been studying at the University of Prague on leave of absence, and his place has been taken by Mr. O. L. Clark, who has spent three years in German universities and was at one time assistant to Prof. L. Jost of Strassburg University, Elsass.

Many of the lines of investigation which were outlined in our last annual report have been continued, some of them being practically completed and ready for publication. Studies of the diseases of crops and of trees, together with investigations of new methods in tree surgery and of long-distance, high-pressure spraying nozzles especially adapted to shade tree work, have been continued. Some of the nozzles have already proved very satisfactory, and have been reported as cutting the expense of spraying one-half, without any decrease in efficiency. One has been patented in the writer's name and assigned to the college, with the provision that any income derived from its sale shall be used by this department subject to the approval of the committee on experiment department and of the director of the station.

Study has been made of a new bacterial disease of the tomato, and experiments made with extermination of weeds in lawns, etc., and tests of various proprietary sprays and fungicides and of crude by-products recommended as soil fungicides and sprays, some of which have proved very efficient in controlling the potato scab. (See twenty-fifth annual report.)

Experiments relating to the exclusion of roots from drain tile have been continued, and positive results obtained. Experiments with chemical methods to destroy horsetail (*Equisetum*), one of the worst weeds in cranberry bogs, also give promise of being successful. Attention has been given to the influence of soil moisture on seed germination, and some problems relating to the stimulating effects on crops of various gases have been taken up. Further study is being made of soil sterilization, particularly of new methods; and also of malnutrition of plants.

A number of problems properly coming under the Adams fund project, and covering in a broad way the effects of meteorological conditions on plants, are being studied as follows: the relation of light to burning from spraying with fungicides and insecticides; relation of light to burning from miscible oils; nature and cause of burning by fumigation with various gases; effects of electricity on nitrogen fixation in soils and on the stimulation of plants in general.

Some of these investigations have been published during the past year in Bulletin No. 144, "The Relation of Light to Greenhouse Culture," a physiological and pathological study of the subject; another paper dealing with the relation of light to burning from miscible oils is in preparation; and still others on research problems which have been studied for some time in our laboratory.

REPORT OF THE ENTOMOLOGIST.

H. T. FERNALD. √

The entomological work of the experiment station during 1913 has been mainly along lines indicated in previous reports. It has not seemed wise to take up many new subjects for investigation, but, instead, to devote most of the time available to those already under way.

Experiments for the control of the onion maggot, begun in 1912, were discussed in the last annual report. The work of the first season indicated that the methods recommended by most writers were either ineffective or too costly for practical use. The season of 1913 was therefore devoted to the testing of new materials as insecticides, particularly applied during the planting process, in order to avoid the expense of special applications. None of the materials thus tested proved to be entirely satisfactory, though one or two were sufficiently so to warrant repetition the coming year, when further experiments will accordingly be made.

Studies on the marguerite leaf miner (*Phytomyza chrysanthemi* Kow.) have been made at intervals at this station for a number of years, as opportunity offered. The work has at last been completed, the entire life history of this greenhouse pest having been worked out, together with methods for its control, and the completed paper by Mr. M. T. Smulyan is about ready for publication.

Observations of the dates of hatching of the more important scale insects of this region have been continued, and the data which have been accumulating on this subject should prove of much value, at least locally. The work should be continued at least two or three years longer.

The box leaf miner (*Monarthropalpus buxi* Lab.), a recent arrival in this country, has caused much injury to box trees and hedges. Its life history and habits are little understood, and a study of this subject and of control methods has been begun.

Tests of various insecticides have been made from time to time, though in most cases sufficient opportunity was not available for anything like sufficient experiments to permit final conclusions. Of the materials tested, the dry arsenate of lead manufactured by the Corona Chemical Company proved very satisfactory, as did also Bowker's lime sulfur prepared by the Bowker Chemical Company, and lead arsenate paste furnished by the Powers, Weightman, Rosengarten Company. Kylscale and soluble sulfur did not give as satisfactory results in controlling the San José scale as had been hoped, though many of the insects were undoubtedly destroyed.

Under the Adams fund, work has been continued on the projects already authorized. In the study of the importance of wasps as parasites it had already been found that any determination of this for the different kinds must necessitate a recognition of the different species, of their distribution and relative abundance. To clear up these points, a study of the material from this country in Europe was necessary, and fortunately this became possible last year. The way is now clear to continue this work on a sound basis as a result of these studies, and it is being prosecuted as rapidly as possible.

The tests of various insecticides, referred to in previous reports, have been continued, and about 4,000 are now recorded. The results thus far have been as satisfactory as could be expected, and the project will be continued.

The work of the apiarist of the station is stated as follows: —

As reported in person to Dr. Evans, Sept. 29, 1913, the Adams fund project of the apiarist of the station has progressed along its originally intended lines. Effort was made to ascertain the number of visits per unit of time which are made by a bee to flowers, as, for instance, to the clover. The visits are a complex of reactions, which thus far are interpreted with consideration of weather, abundance of nectar in the flowers, the frequency of visits of other bees to the same flower, the time of day, and nectar-yielding conditions. Earlier experiments with bees in reaction to tissue paper flowers evinced that either touch or odor was a factor as well as color. Here again odor apparently was involved in the case of clover. Apart from the jurisdiction of the college, it was reported that significant findings had been made concerning dissemination, persistency, and especially the incipient stages of the brood diseases of bees, respectively European foul brood, American foul brood and sac brood. Observations were also made concerning the curative value of the so-called "dequeening process," and the importance of Italianization. Equipment has been procured for an experiment the current month concerning stimuli which attract bees.

The discovery of an active and very efficient parasite of the San José scale was made at this station during the year, and deserves somewhat more than casual mention.

Numerous specimens of this scale are examined each year. Generally only a few parasites have been noted, these being the well-known *Aphelinus fuscipennis* How., and not sufficiently abundant to be of any importance. In the fall of 1912, however, a large amount of parasitism was observed, and the parasites were accordingly bred. They proved to be an unknown species which is described and published in the Annals of the Entomological Society of America for March, 1913, by Mr. D. G. Tower, a graduate student at the college, in whose hands this subject had been placed to follow up. During the year Mr. Tower has continued his observations on this insect and has its life history nearly completed.

During 1913 this parasite has been extremely abundant, and in many cases has parasitized over 90 per cent. of the scales on the branches of the plants examined. It has also been found in other parts of the State, and has been reported from Connecticut, New York and Pennsylvania, and is probably still more widely distributed. The station has sent out supplies of parasitized scales to a number of other States and is still supplying material on request.

That this insect may be of great value is evident by its work. It is only fair, however, to call attention to the fact that such insects often appear in great abundance for a time, after which they become less numerous and accordingly far less important. In any case, so long as a single San José scale can give rise to over three billions of descendants in a single year (Bulletin 4, Division of Entomology, United States Department of Agriculture) it can hardly be anticipated that spraying for this insect can be omitted.

The correspondence during the year has been fully as large as heretofore, and many insects sent in have been species of which little is known. This has necessitated a large amount of research, and often the rearing of the insects before satisfactory information as to methods of control could be furnished.

Insects found by the nursery inspectors of the State on imported nursery stock are sent to this station for identification, and this phase of the work, being quite novel, has also taken considerable time. A number of foreign pests not at present established in this country have been discovered in this way.

The collections have constantly increased in size and value. There are now probably considerably over 100,000 pinned specimens, besides many samples of work done by insects, a large number of mounted slides and many alcoholic specimens. The proper care of a collection of this size, and of adding to it material collected each year, is sufficient to occupy the entire time of one man. At present it is partially attended to as opportunity offers. The time is rapidly approaching when it must receive more attention or greatly lose in value.

REPORT OF THE POULTRY HUSBANDMAN.

JOHN C. GRAHAM.

The chief investigations started last year, and which are still in progress, consist of a thorough study of the capacity of each hen to produce (*a*) eggs, (*b*) fertile eggs, (*c*) hatchable eggs, (*d*) viable chicks, (*e*) vigorous adults, and of the ability of each bird to transmit these qualities to its progeny.

Secondary studies are being made of the inheritance of various color and form characteristics. To this end, 144 pullets were trapnested through the year 1913.

During the breeding season eggs were incubated, a record being kept of each egg and its fate, and over 2,000 chicks were hatched, as many as possible being reared to maturity.

Feather charts of all adults have been made. Besides the main experiments, various trials have been made, from time to time, of such problems as suggest themselves with a view of testing their possibilities. Considerable time has been spent on autopsies of birds sent in by poultrymen.

During the last half of the hatching season it was found that coccidiotis had gained such headway that a large number of chicks were lost from this disease, besides injuring many more. There are so many obscure points in the life history of the causative organism that a large amount of time has to be devoted to its study, to the disadvantage of our other investigations; however, certain points regarding the disease had to be made out before we could proceed with our other work with confidence. These points have now been studied with sufficient care to outline a favorable method of management.

VETERINARY DEPARTMENT.

ON THE DIAGNOSIS OF INFECTION WITH BACTERIUM PULLORUM IN THE DOMESTIC FOWL.

By GEO. EDWARD GAGE

WITH THE ASSISTANCE OF

BERYL H. PAIGE AND HAROLD W. HYLAND

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During the last two years the scientific evidence at hand concerning the rôle of *Bacterium pullorum* (Rettger) in bacillary white diarrhœa of young chicks and relations of it to ovarian infection in adult fowls has been most conclusive. Rettger and Stoneburn[1] pointed out the fact that adult hens were the original source of infection to young chicks suffering with bacillary white diarrhœa.

In their report of 1911[2] they further substantiate the results of the previous paper in that adult hens are the original source of infection; that eggs from infected hens may contain the organism in the yolk.

In a third report, 1912,[3] they fully support statements of their previous work concerning ovarian infection, and they conclude that the ovaries may become infected by contact of the hens with infected hens or by artificial infection of the litter. "The infection is, in all probability, acquired through the mouth."

Gage, in 1910–11,[4] in publication of reports from experiments conducted at the Maryland Experiment Station, concluded that Rettger and Stoneburn were correct in their work of the previous year, corroborating the fact that white diarrhœa, as poultrymen understand it, is a bacillary disease caused by *Bacterium pullorum* (R), and that the hen is the original

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[1] Rettger, L. F., and Stoneburn, F. H.: Bulletin No. 60, 1909, Storrs Agricultural Experiment Station. "Bacillary white diarrhœa of young chicks."

[2] Rettger, L. F., and Stoneburn, F. H., Bulletin No. 68, 1911, Storrs Agricultural Experiment Station. "Bacillary white diarrhœa of young chicks" (second report).

[3] Rettger, L. F., Stoneburn, F. H., and Kirkpatrick, Wm. F.: Bulletin No. 74, 1912. "Bacillary white diarrhœa of young chicks" (third report).

[4] Gage, Geo. Edward: "Notes on ovarian infection with *Bacterium pullorum* (Rettger) in the domestic fowl." Journal Medical Research, Vol. XXIV., No. ; N. S., Vol. XIX., No. 3; June, 1911, pp. 491–496.

source of infection, transmitting the organism from the ovary to the eggs.

Jones, in his reports of 1910[1] and 1911,[2] again supports the work of Rettger and Stoneburn, and also finds that the local disease in the ovary of adult fowls may be produced by the intravenous injections of *Bacterium pullorum.*

From these reports it can be seen that the problem now consists in methods of determining the presence of the virus in adult hens. From examination of eggs it has been almost impossible to make a diagnosis of this infection within a short time, since *Bacterium pullorum* is eliminated so irregularly that it is necessary, often, to examine all eggs laid by a suspected hen over a long period.

Jones[3] suggested the use of an agglutination similar to that used in the diagnosis of glanders and contagious abortion for detecting ovarian infection, and in a later paper[4] has given an excellent example of the value of the macroscopic agglutination test for detecting individuals harboring *B. pullorum.*

It is the object of this paper to present the results of the work conducted in the investigational laboratory of the department of veterinary science concerning the diagnosis of this ovarian infection in adult hens by egg analysis and by macroscopic agglutination tests, together with data which have been obtained concerning the various factors which must be considered in making the tests. It shall also serve to demonstrate the practicability of these tests as a routine laboratory procedure, the work having been performed in many respects by three different technicians.

The subjects used for these experiments were all suspected of harboring the virus of *Bacterium pullorum.* The organism had been detected in the yolk of eggs from hens Nos. 267, 792, 452, 714 and 464 prior to their arrival at the laboratory. Hens Nos. 1, 2, 4, 5, 6, 7, 8, 10, 13, 18, 22, 34, 35, 46, 48, 49, 52, 53, 60, 61, 77, 312, 315, 618 and 2096 were all suspects. Hens Nos. 1, 2, 4, 5, 6, 7, 8, 10, 13, 18, 22, 48, 52 and 53 had been inoculated intravenously with 1 c.c. of a bouillon suspension of a culture of *Bacterium pullorum*[5] known according to the filing-denotation of *Bacterium pullorum* in this laboratory as M., which had been isolated from the ovaries of a white Orpington pullet, and proven absolutely to be capable of producing the disease in young chicks. Hens Nos. 34, 35, 46, 49, 60, 61, 77, 312, 315, 618 and 2096 had been closely associated with hens which had received the intravenous injection, but, so far as the author has been able to ascertain, only for a short time. Since the data on these last

[1] Jones, F. S.: "Fatal septecemia or bacillary white diarrhœa in young chickens." Annual Report of the New York State Veterinary College for 1910, pp. 111–129.

[2] Jones, F. S.: "Further studies on bacillary white diarrhœa in young chickens." Report, New York State Veterinary College, 1910–11, pp. 69–88.

[3] Jones, F. S.: Report, New York State Veterinary College for 1910–11, p. 76.

[4] Jones, F. S.: "The value of the macroscopic agglutination test in detecting fowls that are harboring *Bact. pullorum.*" Journal Medical Research, Vol. XXVII., No. 4; N. S., Vol. XXII., No. 4, pp. 485–495.

[5] Gage: "Notes on ovarian infection with *Bacterium pullorum* in the domestic fowl." Journal Medical Research, Vol. XXIV., No. 5; N. S., Vol. XIX., No. 3, p. 493.

birds were so incomplete concerning their histories, it was considered wise to put all together and include them all in the tests. Birds Nos. 1, 2, 4, 5, 6, 7, 8, 10, 13, 18, 22, 48, 52 and 53 were all more than three years old, and were sent to this laboratory through the kindness of Director H. J. Patterson of the Maryland Agricultural Experiment Station, where the author had started work to determine the possibility of artificial infection of ovarian tissue by intravenous injections of the organisms, — work which was interrupted before final results could be obtained.[1] Jones,[2] however, was successful in his attempts to bring about ovarian infection with *Bact. pullorum* by the injection of pure cultures of the organism into the blood circulation of hens.

All individuals retained for these tests were trap-nested and complete egg records kept of each hen.

Methods employed in the Examination of Eggs for Bacterium Pullorum.

The object primarily in making the examination of all eggs laid by these suspected hens was to determine if possible the presence of the organism in the yolk, which would be of value in checking up the work in connection with any of the serum reactions which later might prove positive. The method used for these egg analyses was essentially that used by Rettger.[3] Eggs were allowed to remain several minutes in carbolic acid (1–40) and dried with sterile absorbent cotton. The end of the egg was sterilized by flaming, the flamed portion cut around with sterile scissors. The albumin was carefully separated from the yolk and the yolk inserted into a large test tube (Buchner type) containing about 30 c.c. sterile bouillon. In the first part of the egg-testing work fresh eggs were studied, but later the eggs were incubated prior to the testing, and in some instances sufficiently long for embryos to develop. In such cases a sterile platinum loop or scissors were used to aid in freeing the embryo from the shell and albumin. If embryo was very large it was inserted into sterile bouillon along with the rest of the yolk. The disintegrated egg yolks in bouillon were placed in the incubator at 38° C. and allowed to remain there for varying lengths of time, the shortest period being twenty-four hours and the longest two hundred and eighty hours. After tubes were taken from bacteriological incubator the material was thoroughly mixed and four samples streaked on four different tubes of agar. These were placed in the bacteriological incubator and examined macroscopically for the presence of the typical *Bact. pullorum* colonies at the end of twenty-four, forty-eight and seventy-two hours. A tube was not considered negative until it had been allowed to incubate for

[1] Work referred to by Dr. Rettger in Bulletin No. 74, Storrs Agricultural Experiment Station Storrs, Conn., p. 162, line 12.

[2] Jones, F. S., "Further studies on bacillary white diarrhœa in young chickens." Report, New York State Veterinary College, 1910–11, pp. 69–88.

[3] Rettger, L. F., and Stoneburn, F. H., Bulletin No. 68, 1911, Storrs Agricultural Experiment Station, "Bacillary white diarrhœa of young chicks" (second report).

seventy-two hours. In many cases when there was doubt concerning organism, all materials were plated out and colony again streaked from such plates.

In view of the fact that many inquiries had been received here at this laboratory concerning the egg test for the determination of this organism, it was decided worth while to test all eggs laid by these suspected hens, and also to record what effect the retention of egg prior to testing, and length of time egg material remained in the bacteriological incubator at 38° to 39° C., had in facilitating isolation of the organism.

In tables 1, 2 and 3 are exhibited the data obtained from the egg tests tabulated to show when egg was laid, by which hen laid, and whether the organism was isolated from the hen, a fact designated by a plus sign. It also shows to how long a period of incubation the egg material in bouillon was submitted before being streaked on the agar slants.

During the period of making the first egg tests all eggs were retained at room temperature until tested, or they were tested on the same day, soon after laying. Later, however, it was found advisable to retain at the temperature of the bacteriological incubator, about 39° C., before inserting in sterile bouillon, to afford perhaps a preliminary proliferation of the organism.

TABLE 1.

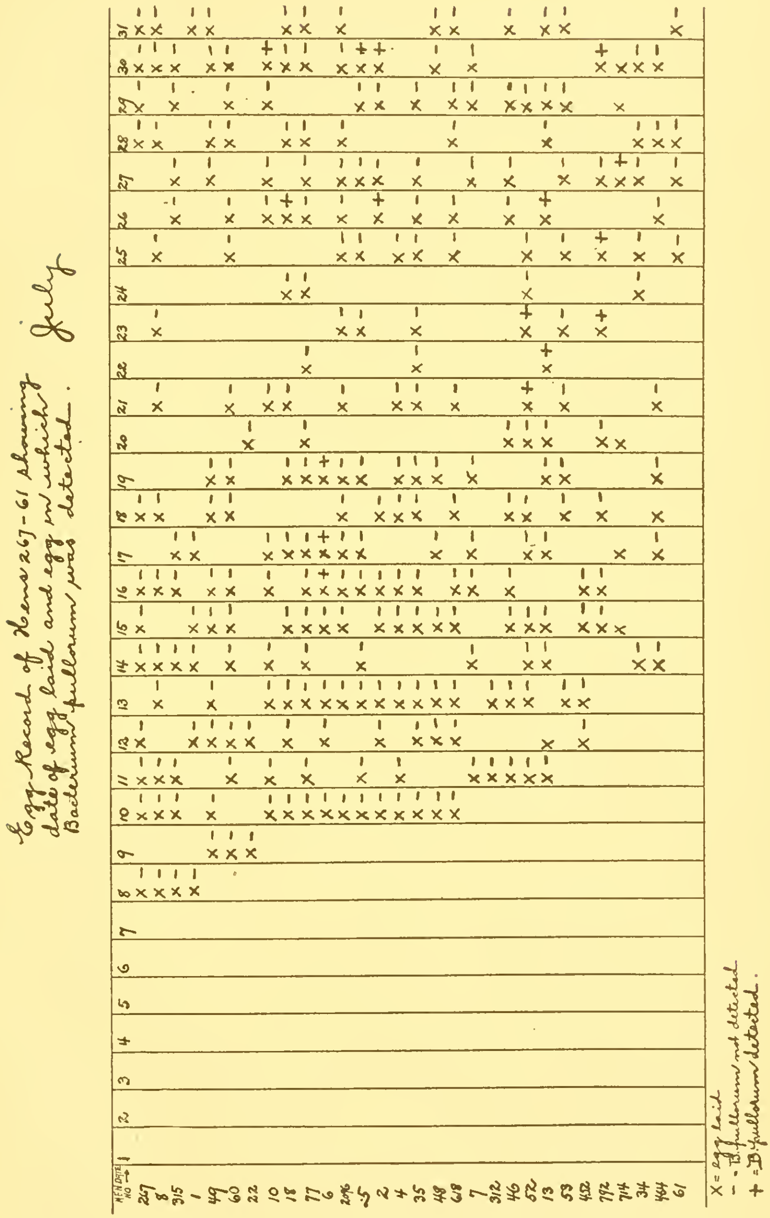
Egg Record of Hens 267-61 showing date of egg laid and egg in which Bacterium pullorum was detected.
July
X = egg laid
− = B. pullorum not detected
+ = B. pullorum detected.

TABLE 2.

Egg Record of Hens 267–61 showing date of egg laid and egg in which Bacterium pullorum was detected. August

Hen No. / Date →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
267	X −	X −		X −	X −		X −						X −		X −	X −	X −		X −		X −	X −	X −	X −			X −				
8		X −		X −		X −		X −				X −		X −		X −		X +							X −			X −		X −	
315	X −	X −		X −	X −		X −	X −				X −		X −		X −	X −		X −	X −		X −		X −		X −		X −		X −	X −
1	X −		X −	X −				X −		X −		X −			X +																
49	X −		X −	X −		X −	X −		X −	X −		X −	X −		X −	X −	X −		X −	X −		X −		X −	X −		X −				X
60	X −		X −													X −	X −		X −	X −		X −									
22													X −	X −		X −	X −		X −	X −		X −				X −					
10	X −	X −		X −		X −				X −		X +		X −	X +		X −														
18						X −					X −		X −			X −	X −				X −		X −		X −						
77	X −	X −		X −	X −	X −	X −	X −	X −		X −	X −	X −	X −		X −	X −	X −	X −		X −		X −	X −			X −			X −	
6			X −								DIED																				
296		X −	X −		X −		X −				X −	X +	X −	X −		X −	X −	X −	X −		X −	X −	X −		X −						
5	X −	X +		X +	X −		X −	X −	DIED																						
2	X −	X −																													
4							X −		X −		X −	X −		X −	X −		X −			X −				X −				X −			X −
35	X −		X −		X −	X −				X −	X −	X −		X −	X −		X −				X −				X −						X −
48		X −	X −		X −			X −			X −								X −		X −		X −		X −						
618	X −	X −		X −	X −		X −	X −	X −		X −	X −		X −	X −	X −		X −	X −	X −		X −		X −							
7	X −		X −	X +		X −		X −			X −		X +		X −		X −		X −		X −										
46	X −			X −		X −	X −	X −		X −	X −	X −		X −	X −																
13		X −	X −		X −	X −		X −	X −	·			X −		X −	X −		X −		X −					X +						
53	X	−			X −	X −			X −	X −		X −	X −		X −	X −		X −		X −											
792	X −	X −			X −	−			X −		X −	X +		X −	X −		X −	X −		X −	X −		X −	X −		X −		X −		X −	
714	X −	X −		X −		X −	X −		X −		X −		X +		X −		X −									X −		X −		X −	
34	X −		X −		X −								X −	X −		X −	X −	X −		X −		X −		X −				X −		X −	
364						X −					X −																				
61	X −	X −		X −	X −				X −		X −	X −		X −	X −	X −		X −										X −		X −	X −

X = egg laid
− = B. pullorum not detected
+ = B. pullorum detected

TABLE 3.

Egg Record of Hens 267–61 showing date of egg laid and egg in which Bacterium pullorum was detected September

HEN NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
267																			X –	X –	X –				X –		X –				
8																															
315		X –		X –		X –				X –		X –		X –			X –			X –	X –										
1																															
49		X –		X –	X –																–										
60	X –		X –	X –																		X –			X –						
22																															
10																															
18																															
77																															
6																															
2096									X –	X –		X –						X –		X –											
5																															
2																															
4				X –	X –				X –	X –		X –				X –					X –		X –								
35		X –																													
48				X –		X +																									
618																															
7																															
312																															
46																															
52																															
13																															
53																									X –						
452																															
792	X –																														
714	X –																				X +										
34								X –																							
464											X –		X +			X +															
61																		X –													

X = egg laid
– = B. pullorum not detected
+ = B. pullorum detected

From Table 4, it can be seen that of the 619 eggs tested *Bacterium pullorum* was detected in eggs laid by hen No. 10, once during July, egg laid 7–30–13; by hen No. 18, once during July, egg laid 7–26–13; by hen No. 6, three times during the month, eggs laid 7–16–13, 7–17–13 and 7–19–13; by hen No. 5, once during month, egg laid 7–30–13; by hen No. 2, twice during month, eggs laid 7–26–13 and 7–30–13; by hen No. 52, twice during month, eggs laid 7–21–13 and 7–23–13; by hen No. 13, twice, eggs laid 7–22–13 and 7–26–13; by hen No. 792, three times, eggs laid 7–23–13, 7–25–13 and 7–30–13; by hen No. 714, once during month, egg laid 7–27–13. During August from hen No. 8 *Bact. pullorum* was isolated from one egg laid 8–18–13; by hen No. 1, once during month, egg laid 8–15–13; by hen No. 10, twice, eggs laid 8–12–13 and 8–15–13; by hen No. 2096, once during month, egg laid 8–12–13; by hen No. 5, twice, eggs laid 8–2–13 and 8–4–13; by hen No. 7, twice, eggs laid 8–4–13 and 8–13–13; by hen No. 13, once, egg laid 8–25–13; by hen No. 792, once, egg laid 8–12–13; by hen No. 714, once, egg laid 8–13–13. During September the organism was isolated from egg of hen No. 48, once, egg laid 9–6–13; by hen No. 714, once, egg laid 9–21–13; by hen No. 464, twice, eggs laid 9–13–13 and 9–16–13.

Of the 16 cultures of *Bacterium pullorum* isolated from eggs in July the yolk material of 13 in sterile bouillon had been retained in bacteriological incubator for more than seventy-two hours. Of the 12 isolated in August, all yolk material in bouillon had been retained in bacteriological incubator more than seventy-two hours. From the 4 isolated in September, the egg material had been in incubator but forty-eight hours. After August 1 it was planned to put all eggs in bacteriological incubator prior to testing, and this brought forth egg material which yielded cultures of *Bacterium pullorum* which had not been detected in July, namely, the infection was detected in hen No. 8, hen No. 1, hen No. 2096 and hen No. 7. By the previous incubation of eggs, for one to three days, the organism had multiplied to such an extent that it was possible to detect the organisms in 7 individuals in whom it had not been detected in July. From egg material incubated in bacteriological incubator at 38° to 39° C. for seventy-two hours or longer it was much easier to detect the organism. Usually it was present in large numbers, and the organism on the agar-slant usually became visible within the first twenty-four hours' incubation. In general it may be stated that egg testing of these hens' eggs yielded better results after this preliminary incubation of the eggs in bacteriological incubator, and it was found always advisable to wait seventy-two hours before considering a sample negative as regards colonies on subsequent agar streaks.

From what has been determined here, and from the work of Rettger and Jones, it can be clearly seen that diagnosis by egg testing is impractical. In some cases, however, the egg testing has given results with the examination of the first few eggs. According to the work in this laboratory, it has been found that if a bird is badly infected persistence in egg testing will usually yield a positive result. Of the 619 eggs tested from hens in

TABLE 4.

TABLE SHOWING WHEN EGG WAS LAID, HEN NUMBER, NUMBER OF HOURS MATERIAL WAS RETAINED IN BACTERIOLOGICAL INCUBATOR

+ = ORGANISM FOUND
− = ORGANISM NOT FOUND

JULY	24 HRS	43 HRS	48 HRS	65 HRS	72 HRS	88 HRS	90 HRS	97 HRS	110 HRS	120 HRS	136 HRS	140 HRS	163 HRS	168 HRS	190 HRS	210 HRS	256 HRS	263 HRS	283 HRS
	6 7/16 +	22 7/20 -	267 7/8 -	267 7/12 -	267 7/10 -	267 7/18 -	267 7/16 -	8 7/28 -	315 7/26 -	8 7/21 -	267 7/28 -	1 8/3 -	60 7/19 -	267 7/28 -	8 7/25 -	267 7/31 -	61 7/28 -	49 8/2 -	618 7/28 -
			267 7/11 -	8 7/13 -	8 7/8 -	8 7/8 -	267 7/29 -	49 7/27 -	315 7/27 -	8 7/23 -	315 7/30 -	49 8/3 -	35 7/29 -		60 7/25 -	8 7/31 -			13 7/28 -
	35 8/2 -		267 7/14 -	8 7/14 -	8 7/10 -	315 7/7 -	315 7/6 -	49 7/28 -	60 7/26 -	60 7/21 -	49 7/30 -	60 8/3 -	48 7/30 -		10 7/26 -	1 7/31 -			
			267 7/15 -	1 7/8 -	315 7/10 -	1 7/7 -	315 7/29 -	10 7/27 -	77 7/26 -	10 7/21 -	60 7/28 -	35 8/3 -	46 7/31 -		18 7/26 +	49 7/31 -			
			8 7/11 -	1 7/12 -	315 7/11 -	49 7/8 -	18 7/5 -	18 7/28 -	77 7/27 -	18 7/21 -	60 7/29 -	7 8/3 -	53 7/19 -		2096 7/25 -	10 7/30 +			
			8 7/16 -	60 7/12 -	49 7/9 -	60 7/8 -	5 7/16 -	2 7/29 -	77 7/28 -	77 7/20 -	60 7/30 -	61 8/4 -	53 7/19 -		5 7/25 -	18 7/31 -			
			8 7/30 -	22 7/12 -	49 7/19 -	10 7/7 -	35 7/16 -	618 7/29 -	2096 7/26 -	77 7/12 -	10 7/29 -		AUGUST		4 7/25 -	77 7/31 -			
			315 7/8 -	18 7/12 -	60 7/9 -	18 7/7 -	618 7/16 -	46 7/27 -	2096 7/27 -	77 7/24 -	18 7/30 -		267 8/1 -		35 7/25 -	2096 7/31 -			
			315 7/14 -	77 7/13 -	22 7/9 -	77 7/7 -	7 7/16 -	34 7/27 -	5 7/27 -	2096 7/21 -	2096 7/28 -		8 8/2 -		618 7/25 -	5 7/29 -			
			1 7/14 -	77 7/15 -	10 7/10 -	77 7/19 -	46 7/16 -	464 7/28 -	2 7/26 +	2096 7/23 -	2096 7/30 -		315 8/24 -		52 7/25 -	48 7/31 -			
			1 7/15 -	6 7/12 -	10 7/11 -	6 7/17 +	13 7/5 -	AUGUST	2 7/26 -	5 7/23 -	5 7/30 +		315 8/26 -		53 7/25 -	618 7/31 -			
			49 7/13 -	2096 7/13 -	18 7/10 -	6 7/19 +	452 7/6 -	315 8/7 -	35 7/26 -	4 7/21 -	2 7/30 +		315 8/28 -		792 7/25 +	52 7/29 -			
			49 7/15 -	5 7/13 -	18 7/19 -	2096 7/18 -	714 7/7 -	2096 8/7 -	35 7/27 -	35 7/21 -	7 7/29 -		315 8/30 -		61 7/25 -	13 7/31 -			
			49 7/16 -	2 7/12 -	77 7/10 -	5 7/7 -	AUGUST	618 8/7 -	618 7/26 -	35 7/22 -	7 7/30 -		315 8/31 -			53 7/31 -			
			60 7/11 -	4 7/12 -	6 7/10 -	2 7/18 -	267 8/5 -	618 8/15 -	7 7/27 -	35 7/23 -	46 7/29 -		49 8/1 -			34 7/28 -			
			60 7/14 -	4 7/13 -	2096 7/10 -	4 7/18 -	267 8/7 -	618 8/16 -	46 7/26 -	618 7/21 -	792 7/30 +		49 8/24 -			61 7/31 -			
			60 7/15 -	35 7/12 -	2096 7/19 -	4 7/19 -	267 8/24 -	7 8/15 -	18 7/26 +	46 7/20 -	714 7/30 -		49 8/25 -			AUGUST			
			60 7/16 -	35 7/13 -	5 7/10 -	35 7/8 -	267 8/27 -	7 8/17 -	53 7/27 -	52 7/21 +	34 7/30 -		49 8/27 -			267 8/2 -			
			10 7/13 -	35 7/15 -	5 7/9 -	35 7/9 -	8 8/6 -	714 8/7 -	792 7/27 -	52 7/23 +	464 7/30 -		49 8/31 -			315 8/1 -			
			10 7/14 -	48 7/12 -	2 7/10 -	48 7/7 -	8 8/8 -		714 7/27 +	52 7/24 -	AUGUST		22 9/26 -			315 8/2 -			
			10 7/16 -	48 7/13 -	4 7/10 -	618 7/9 -	8 8/25 -	315 9/2 -	714 7/29 -	13 7/18 -	5 8/1 -		18 8/25 -			1 8/1 -			
			18 7/13 -	618 7/12 -	4 7/10 -	7 7/7 -	8 8/28 -	315 9/4 -	464 7/26 -	13 7/19 -	46 8/1 -		77 9/24 -			60 8/1 -			
			77 7/14 -	7 7/14 -	35 7/10 -	46 7/18 -	8 8/30 -	49 9/2 -	61 7/27 -	13 7/20 -	792 8/1 -		77 8/27 -			10 8/1 -			
			77 7/16 -	46 7/15 -	48 7/10 -	52 7/18 -	315 8/8 -	49 9/4 -	AUGUST	13 7/22 +			77 8/30 -			10 8/2 -			
			77 7/30 -	52 7/3 -	48 7/19 -	53 7/18 -	315 8/12 -	49 9/5 -	267 8/15 -	53 7/21 -			2096 8/25 -			77 8/1 -			
			6 7/13 -	52 7/15 -	618 7/10 -	792 7/18 -	1 8/8 -	60 9/1 -	8 8/14 -	53 7/23 -			4 8/24 -			77 8/2 -			
			6 7/15 -	13 7/12 -	53 7/13 -	464 7/7 -	1 8/10 -	60 9/3 -	8 8/18 +	792 7/23 +			4 8/28 -			2096 8/2 -			
			2096 7/5 -	452 7/12 -	792 7/20 -	464 7/9 -	49 8/6 -	60 9/4 -	315 8/14 -	714 7/20 -			4 8/31 -			5 8/2 +			
			2096 7/6 -	792 7/15 -	AUGUST	AUGUST	49 8/7 -	4 9/4 -	49 8/13 -	34 7/24 -			35 8/25 -			2 8/1 -			
			2096 7/7 -	464 7/16 -	315 8/5 -	267 8/3 -	49 8/9 -	4 9/5 -	49 8/15 -	34 7/25 -			35 8/31 -			2 8/2 -			
			5 7/11 -		5 8/7 -	267 8/16 -	49 8/10 -	35 9/2 -	22 8/13 -	464 7/21 -			48 8/25 -			35 8/1 -			
			5 7/14 -		4 8/11 -	267 8/7 -	49 8/12 -	48 9/4 -	22 8/14 -	AUGUST			618 8/24 -			48 8/2 -			
			2 7/13 -		7 8/11 -	8 8/12 -	10 8/6 -	792 9/1 -	10 8/14 -	267 8/4 -			7 8/1 -			618 8/1 -			
			2 7/15 -		618 8/9 -	8 8/16 -	10 8/10 -	714 9/1 -	18 8/13 -	267 8/19 -			13 8/25 +			618 8/2 -			
			2 7/16 -			315 8/16 -	10 8/2 +		77 8/13 -	267 8/21 -			792 8/26 -			13 8/2 -			
			4 7/15 -			1 8/2 -	18 8/11 -		77 8/14 -	267 8/22 -			792 8/28 -			53 8/2 -			
			4 7/16 -			1 8/15 +	77 8/6 -		77 8/18 -	267 8/23 -			792 8/30 -			792 8/2 -			
			48 7/15 -			49 8/16 -	77 8/7 -		2096 8/18 -	8 8/4 -			714 8/26 -			714 8/1 -			
			618 7/13 -			49 8/7 -	77 8/8 -		4 8/14 -	315 8/4 -			714 8/28 -			714 8/2 -			
			618 7/15 -			60 8/16 -	77 8/9 -		35 8/14 -	315 8/19 -			714 8/30 -			61 8/2 -			
			7 7/11 -			60 8/7 -	77 8/11 -		35 8/11 -	315 8/26 -			34 8/1 -						
			312 7/4 -			22 8/16 -	77 8/12 -		618 8/14 -	315 8/22 -			34 8/24 -						
			312 7/13 -			22 8/7 -	2096 8/5 -		618 8/19 -	1 8/4 -			61 8/1 -						
			46 7/11 -			10 8/16 +	2096 8/11 -		7 8/13 +	49 8/4 -			61 8/28 -						
			46 7/13 -			10 8/17 -	2096 8/12 +		46 8/14 -	49 8/19 -			61 8/30 -						
			52 7/11 -			18 8/16 -	2096 8/3 -		53 8/8 -	49 8/20 -			61 8/31 -						
			52 7/14 -			18 8/17 -	2096 8/6 -		792 8/14 -	60 8/19 -									
			52 7/17 -			77 8/14 -	2096 8/7 -		34 8/14 -	60 8/20 -									
			13 7/11 -			77 8/16 -	5 8/5 -		34 8/18 -	60 8/22 -									
			13 7/14 -			618 8/8 -	5 8/8 -		61 8/14 -	22 8/19 -									
			13 7/17 -			13 8/15 -	4 8/7 -		61 8/15 -	22 8/20 -									
			452 7/13 -			13 8/16 -	4 8/9 -			22 8/22 -									
			452 7/15 -			13 8/8 -	4 8/12 -			10 8/4 -									
			792 7/16 -			53 8/5 -	4 8/15 -			18 8/6 -									
			714 7/15 -			53 8/16 -	4 8/17 -			18 8/21 -									
			34 7/14 -			792 8/15 -	35 8/5 -			18 8/23 -									
			SEPTEMBER			34 8/6 -	35 8/6 -			77 8/4 -									
			267 9/19 -			34 8/7 -	35 8/10 -			77 8/5 -									
			267 9/20 -			61 8/6 -	35 8/11 -			77 8/9 -									
			267 9/21 -			61 8/8 -	35 8/15 -			77 8/21 -									
			267 9/25 -				48 8/5 -			77 8/23 -									
			267 9/27 -				48 8/8 -			6 8/3 -									
			315 9/6 -				48 8/11 -			2096 8/3 -									
			315 9/10 -				618 8/5 -			2096 8/19 -									
			315 9/12 -				618 8/8 -			2096 8/21 -									
			315 9/14 -				618 8/9 -			2096 8/22 -									
			315 9/17 -				618 8/11 -			2096 8/23 -									
			315 9/20 -				618 8/12 -			5 8/4 +									
			315 9/21 -				7 8/6 -			4 8/20 -									
			60 9/22 -				7 8/8 -			35 8/21 -									
			60 9/25 -				46 8/6 -			48 8/3 -									
			2096 9/9 -				46 8/8 -			48 8/19 -									
			2096 9/10 -				46 8/10 -			48 8/21 -									
			2096 9/12 -				46 8/11 -			48 8/23 -									
			2096 9/18 -				46 8/12 -			618 8/4 -									
			2096 9/20 -				46 8/15 -			618 8/20 -									
			4 9/9 -				13 8/6 -			618 8/27 -									
			4 9/10 -				13 8/8 -			7 8/4 +									
			4 9/12 -				13 8/9 -			7 8/9 -									
			4 9/16 -				13 8/13 -			7 8/21 -									
			4 9/21 -				53 8/6 -			46 8/4 -									
			4 9/23 -				53 8/9 -			46 8/7 -									
			48 9/16 +				53 8/10 -			13 8/3 -									
			53 9/25 -				53 8/12 -			13 8/5 -									
			714 9/21 +				53 8/13 -			13 8/20 -									
			34 9/8 -				792 8/9 -			53 8/5 -									
			464 9/11 -				792 8/11 -			53 8/20 -									
			464 9/13 +				792 8/12 +			792 8/5 -									
			464 9/16 +				792 8/7 -			792 8/20 -									
			61 9/18 -				792 8/8 -			792 8/21 -									
							714 8/6 -			792 8/23 -									
							714 8/9 -			792 8/24 -									
							714 8/11 -			714 8/4 -									
							714 8/13 +			34 8/3 -									
							714 8/15 -			34 8/20 -									
							714 8/17 -			34 8/22 -									
							34 8/5 -												
							34 8/13 -												
							464 8/6 -												
							464 8/11 -												
							61 8/5 -												
							61 8/11 -												
							61 8/12 -												

this experiment during July, August and the first part of September 32 were found to contain the organism, detected in hens Nos. 10, 18, 6, 5, 2, 52, 13, 792, 8, 1, 2096, 7, 714, 267, 48 and 464. With hen No. 10, 11 eggs were tested, covering a laying period of seventeen days, before the organism was detected. With hen No. 18, 8 eggs were tested, covering a laying period of sixteen days prior to its detection. With hen No. 6, 5 eggs were tested, covering a laying period of six days. With hen No. 5, 12 eggs were tested, covering a laying period of twenty days. With the other 11 infected birds it varied from the 6th to the 21st egg laid before *Bacterium pullorum* was detected for the first time, and the laying periods varied from eight to sixty-one days (see Table 5 on page 10).

It is interesting to note at this point that all the hens, except 22, which were received from the Maryland Experiment Station, previously inoculated intravenously with a pure culture of *Bacterium pullorum*, after two years, showed positively the ovarian infection. This is in full agreement with the work of Dr. Jones, — that it is possible to cause local infection and cause such infection through the blood system.

As stated before, it has not been the primary object of these egg tests to make an exhaustive study of the value of diagnosis of ovarian infection by this method, but it has been of importance to determine by it if possible the number of these hens infected, to use as a check on the work on agglutination which was to follow.

Therefore, according to these tests hens Nos. 10, 8, 6, 5, 2, 52, 13, 792, 714, 8, 1, 2096, 7, 48 and 464 are all infected hens, the organism having been demonstrated conclusively in their eggs. It should also be stated that prior to starting experiments with these birds the organism had been detected in hen No. 267. From our work just cited it can be seen that in those hens which did lay eggs containing *Bact. pullorum*, the elimination from the ovary was so irregular that it would be impossible to make a diagnosis in a short time.

Since there was at hand such good material for study it was considered of importance to study the macroscopic agglutination test, as suggested by Jones [1, 2], — as regards the practicability of the tests, the test fluids and important steps to be observed in making the diagnosis, — and to carry out the test with three laboratory technicians to determine the value of this macroscopic test as a laboratory procedure for the diagnosis of this infection in adult hens.

This test depends upon the specific agglutinin elaborated in the blood serum of hens harboring the organism. The test requires a test fluid containing a suspension of *Bacterium pullorum* in 0.85 per cent. salt solution, preserved with 0.5 per cent. carbolic acid, and the specific agglutinin, diluted in varying amounts from suspected individuals. The agglutinins act on dead as well as living organisms.

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[1] Jones, F. S.: Report, New York State Veterinary College for 1910–11, p. 76.

[2] Jones, F. S.: "The value of the macroscopic agglutination test in detecting fowls that are harboring *Bact. pullorum*." Journal Medical Research, Vol. XXVII., No. 4; N. S., Vol. XXII., No. 4, pp. 485–495.

TABLE 5.

HEN NO.	No. OF EGGS LAID BEFORE B. PULLORUM WAS DETECTED	LAYING PERIOD IN DAYS
10	11	20
18	8	16
6	5	6
5	12	20
2	7	16
52	7	10
13	8	15
792	5	8
714	4	12
8	21	39
1	13	38
2096	21	33
7	11	24
48	19	58
464	12	61

From some preliminary tests it was found that the living test fluids gave little better results. For this reason it was decided to carry out our work, using the living organisms in preparing the various test fluids.

The Test Fluid.

Before preparing any of our test fluids for these macroscopic agglutination reactions, all strains of *Bacterium pullorum* were thoroughly tested out to establish their pathogenic powers. The *Bacterium pullorum* material had been isolated from 7 different sources, and was designated S_1 (Strain No. 1) S_2, S_3, S_4, S_5, S_6 and S_7, and represented cultures of *Bacterium pullorum* isolated by the author from chicks which had died of the disease from an infected flock of hens in western Massachusetts; from another chick, dead of the disease; from an infected flock of more than 400 hens from eastern Massachusetts; from a fresh egg laid by a hen in this infected flock; from the ovarian tissue of a badly infected hen in the State of Maryland; from a chick which had died after experimental inoculation with a pure culture isolated from ovarian tissue; from a strain isolated from Connecticut epidemics and furnished to the author three years ago by Dr. Rettger of Yale University. The last, or Strain No. 7, was recovered from a local epidemic. These strains were all carefully examined for purity, and after due time were obtained in a very active state of growth. Strain No. 4 was finally not used because it appeared to have lost so much of its virulence.

For testing the virulence of these 6 strains of *Bacterium pullorum* 154 day-old chicks, hatched July 10, 1913, were used. They were divided into 7 lots, 22 in each lot. Six of these sets were inoculated with *Bact. pullorum* and the seventh was used for control. The chicks were fed sterilized food and water and were retained in wire animal cages and brooded with stone jugs containing hot water. The litter used was fine shavings which had been sterilized and spread in a layer over floor of cages prior to putting the chicks in. Each chick in the lots to be infected received $\frac{1}{4}$ c.c. of a physiological saline suspension of the various strains of *Bacterium pullorum* subcutaneously. The control lot received $\frac{1}{4}$ c.c. sterile physiological salt solution administered in the same manner. Chicks in pen No. 1 were inoculated with S_1; chicks in pen No. 2, with S_2; chicks in pen No. 3, with S_3; chicks in pen No. 4, with S_5; chicks in pen No. 5, with S_6; chicks in pen No. 6, with S_7; and the chicks in pen No. 7 were the controls.

As soon as chicks died they were carefully autopsied and the liver, heart, unabsorbed yolk and calcar examined for presence of *Bacterium pullorum*. In Table 6 are arranged the mortality records which furnish the evidence of the pathogenicity of these various strains. From each chick, dead of the disease, cultures were retained, and in Table 6 P. signifies that the cultures were recovered from the respective organs in an absolutely pure state. Wherever there is a denotation N.P. it signifies that culture recovered was not pure. However, in no case did the contaminating factor so outgrow or obscure the colony of *Bacterium pullorum* but that it was possible to recover it from some of the tubes. At this point it is sufficient to say that the symptoms — pre-mortem and post-mortem findings of chicks dead of the disease — correspond with those previously studied by the author.[1]

After twenty-five days the tests were considered completed, and Strains Nos. 1, 2, 3, 5, 6 and 7 were all in perfect condition to continue the work with the agglutinations. Pen No. 7, the control lot, never showed any signs of disease, and until a few weeks ago (Dec. 1, 1913) 20 of the 22 were living, healthy, vigorous birds. Only two deaths occurred among the 22 control chicks; one was accidental and the other was killed on account of lameness.

Making the Test Fluid.

Slant agar tubes were inoculated with *Bact. pullorum* and grown in incubator at 38° C. for one or two days. The growth was then washed with carbolated salt solution (0.85 per cent. salt solution containing 0.5 per cent. carbolic acid). The whole volume of washed material should have a very definite cloudy appearance. This was put in the shaking machine and shaken for one-half hour and then passed through sterile absorbent cotton to strain out any clumps of bacteria which might remain. Care should always be observed not to prepare the suspension too thin. A good test fluid should be uniformly turbid. This should be retained on ice or in lower part of refrigerator.

Method of obtaining Blood Serum.

At first the method of cutting a spike of the comb was employed, but since the bird's blood coagulates so quickly if in contact with tissue this was found unsatisfactory. Then the method of cutting the wing vein was employed, and by working carefully with this method it was found to be suitable in every respect for drawing blood in 2 to 10 c.c. quantities, causing but little effect upon the bird. At first great care was used in cutting through the cutaneous tissue until the *vena ulnaris* was reached, and the tissue teased away to make a clean cutting surface for making the incision into the vein. By such treatment it was possible to get the blood under quite ideal conditions, but the bird was submitted to considerable discomfort. Finally it was found that the quicker the cut was made the better the results, and less discomfort for the individual. The procedure finally adopted for drawing about 6 c.c. of blood in a very short time, and one which appeared to cause the individual no apparent discomfort, nor disturb the egg laying later on, was carried out as follows: the bird was laid on its side and the wing laid out near the edge of the table and turned downward to afford a grade for the sample of blood to flow into test tube.

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[1] Gage, Geo. Edward: "Notes on ovarian infection with *Bacterium pullorum* (Rettger) in the domestic fowl." Journal Medical Research, Vol. XXIV., No. 3; N. S. Vol. XIX., No. 3; June, 1911, pp. 491-496.

TABLE 6.

Mortality Records of chicks on test to demonstrate pathogenicity of Bacterium pullorum S_1, S_2, S_3, S_5, S_6 and S_7

Pen no 1 - chicks inoculated subcutaneously with 0.25 c.c. physiological saline suspension Bact. pullorum Strain 1 22 in number. (SEE LEGEND AT BOTTOM OF TABLE)

No.	Date of Death	Heart	Liver	Unabsorbed Yolk	Caeca	Cultures Purified and Filed as No.
1	7-13-13	+ NP	+ P	—	—	H 1
2	7-13-13	+ NP	+ NP	+ NP	+ NP	H 2 L 3
3	7-13-13	+ P	+ P	+ NP	+ NP	H 4 L 5 U 6
4	7-14-13	+ NP	+ NP	+ P		U 7
5	7-14-13	+ P	+ NP	+ NP	+ NP	H 8 L 9
6	7-14-13	+ NP	+ NP	+ NP	—	H 10 L 11
7	7-14-13	+ P	+ P	+ NP	+ NP	H 12 L 13 U 14
8	7-14-13	+ NP	+ NP	+ NP	+ NP	L 15 U 16 C 17
9	7-14-13	+ P	+ P	+ NP	+ NP	H 18 L 19 U 20
10	7-14-13	+ NP	+ NP	+ NP	+ NP	L 21 U 22
11	7-15-13	+ P	+ NP	+ P	+ NP	H 23 L 24 U 25
12	7-15-13	+ NP	+ NP	+ NP	+ NP	H 26 L 27 U 28 C 29
13	7-15-13	+ P	+ P	+ P	+ NP	H 30 L 31 U 32
14	7-16-13	+ NP	+ P	+ NP	+ NP	L 33
15	7-16-13	+ NP	+ NP	+ NP		H 34 L 35 U 36
16	7-16-13	+ NP	+ NP	+ NP	+ NP	H 37 L 38 U 39
17	7-16-13	— NP	— NP	+ NP		U 40
18	7-16-13	+ P	+ P	+ NP	— NP	H 41 L 42 U 43
19	7-17-13	+ NP	+ NP			H 44 L 45
20						
21						
22						

Pen no 2 - chicks inoculated subcutaneously with 0.25 c.c physiological saline suspension Bact. pullorum Strain 2 22 in number

No.	Date of Death	Heart	Liver	Unabsorbed Yolk	Caeca	Cultures Purified and Filed as No.
1	7-12-13	—	—	—	-	
2	7-14-13	— NP	+ NP	+ P	— NP	L 46 U 47
3	7-14-13	— NP	+ NP	+ NP	— NP	H 48 L 49 U 50
4	7-15-13	+ P	+ P	+ NP	+ NP	H 51 L 52 U 53
5	7-15-13	+ NP	+ NP	+ NP	— NP	H 54 L 55 U 56
6	7-1-13	I NP	+ P	+ NP	+ NP	L 57
7	7-16-13	+ NP	+ P	+ P		H 58 L 59 U 60
8	7-16-13	+ NP	+ NP	+ P	+ NP	H 61 L 62 U 63
9	7-16-13	+ NP	+ NP	+ P	+ NP	H 64 U 65
10	7-16-13	+ P	+ P	+ NP	+ NP	H 66 L 67
11	7-16-13	+ P	+ NP	+ P	+ P	H 68
12	7-17-13	+ NP	+ NP	?		U 69
13	7-17-13	+ P	+ P	+ NP	— NP	H 70 L 71 U 72
14	7-17-13	+ NP	+ NP			H 73
15	7-17-13	+ NP	+ NP	+ NP	+ NP	L 74 U 75 C 76
16	7-17-13	I	+ NP	+ NP	I NP	U 77
17	7-17-13	+ NP	+ P	+ P	+ NP	L 78 U 79
18	7-18-13	+ NP	+ NP	+ NP	+ NP	L 80 U 81
19	7-21-13	+ P	+ P	+ NP	+ NP	L 82
20	7-23-13	+ NP	— NP	+ NP	+ NP	H 83
21						
22						

Pen no 3. - chicks inoculated subcutaneously with 0.25 c.c. physiological saline suspension Bact. pullorum Strain 3 22 in number

No.	Date of Death	Heart	Liver	Unabsorbed Yolk	Caeca	Cultures Purified and Filed as No.	No.
1	7-12-13	—	—	—	—		1
2	7-14-13	— NP	+ NP	+ P	+ NP	H 84 L 85 U 85	2
3	7-14-13	— NP	+ P	+ NP	+ NP	L 87	3
4	7-14-13	— NP	+ NP	+ NP	+ NP	H 88 L 89	4
5	7-15-13	— NP	+ P	+ NP	+ NP	H 90 L 91 U 92	5
6	7-15-13	+ P	+ NP	+ NP	+ NP	H 93 L 94 C 95	6
7	7-16-13	+ NP	+ NP	+ NP	+ NP	U 96	7
8	7-16-13	+ NP	+ P	+ NP	+ NP	L 97	8
9	7-16-13	+ NP	+ NP	+ NP	+ NP	H 98 L 99 U 100	9
10	7-16-13	— NP	?	+ NP	?	H 101 U 102	10
11	7-16-13	+ NP	+ NP	+ NP	+ NP	H 103 L 104 U 105	11
12	7-16-13	+ P	+ P	+ P	+ NP	H 106 L 107 U 108 C 109	
13	7-17-13	+ P	+ NP	+ NP	+ NP	H 110 L 111 U 112	
14	7-17-13	?	+ P	+ NP	+ NP	L 113 U 114	
15	7-17-13	— NP	+ NP	+ NP	+ NP	L 115 U 116	
16	7-17-13	+ NP	—	+ NP	+ NP	H 117	
17	7-17-13	+ P	+ NP	+ NP	+ NP	H 118 L 119	
18	7-19-13	— NP	+ NP	+ NP	+ NP	H 120	
19	7-22-13	+ P	+ P	+ P	+ NP	H 121 L 122 U 123	

Pen no 4 - chicks inoculated subcutaneously with 0.25 c.c physiological saline suspension Bact pullorum Strain 5. 22 in number

No.	Date of Death	Heart	Liver	Unabsorbed Yolk	Caeca	Culture Purified and Filed as No.
1	7-13-13	— NP	+ NP	— NP	?	L 124
2	7-14-13	+ NP	+ NP	+ NP	+ NP	H 125 L 126 U 127 C 128
3	7-15-13	+ NP	+ NP	+ NP	+ NP	H 129 L 130
4	7-16-13	—	+ NP	—	+ NP	H 131 L 132 C 133
5	7-16-13	+ NP	+ P	+ NP	?	H 134 L 135 U 136
6	7-16-13	+ P	+ NP	+ P	+ NP	H 137 L 138 U 139 C 140
7	7-16-13	+ NP	+ NP	+ NP	+ NP	H 141 L 142 U 143 C 140
8	7-16-13	— NP	+ NP	+ NP	—	L 145 U 146
9	7-17-13	—	+ NP	+ NP	?	L 147 U 148
10	7-17-13	?	+ NP	+ NP	?	L 149 U 150
11	7-17-13	?	+ NP	+ P	+ NP	L 151 U 152 C 153

Pen no 5 - Chicks inoculated subcutaneously with 0.25 c.c physiological saline suspension Bact. pullorum Strain 6 22 in number.

No.	Date of Death	Heart	Liver	Unabsorbed Yolk	Caeca	Cultures Purified and Filed as No.
1	7-12-13	+ P	+ NP	+ P	+ NP	H 154 L 155 U 156
2	7-13-13	+ P	+ NP	+ P	+ NP	L 157 U 158
3	7-14-13	+ NP	+ P	+ NP	+ P	L 159 U 160
4	7-15-13	+ P	+ P	+ NP	+ P	L 161 U 162
5	7-15-13	+ P	+ P	+ P	+ P	H 163 L 164
6	7-15-13	+ P	+ P	+ P	+ P	H 165 L 166
7	7-15-13	+ P	+ NP	+ P	+	H 167 U 168
8	7-15-13	+ P	+ NP	+ P	+ NP	H 169 L 170 U 171 C 172
9	7-15-13	+ P	+ NP	+ P	+ NP	H 173 L 174 U 175
10	7-15-13	+ P	+ NP	+ P	+ NP	H 176 L 177 U 178
11	7-16-13	+ P	+ P	+ NP	+ NP	H 179 L 180 U 181
12	7-16-13	+ P	+ NP	+ P	+ NP	H 182 L 183
13	7-16-13	+ P	+ NP	+ P	+ NP	H 184 L 185 U 186
14	7-16-13	+ NP	+ NP	+ P	+ NP	U 187

Pen no 6 - Chicks inoculated subcutaneously with 0.25 c.c physiological saline suspension Bact pullorum Strain 7, 22 in number

No.	Date of Death	Heart	Liver	Unabsorbed Yolk	Caeca	Culture Purified and Filed as No.
1	7-13-13	+ NP	—	+ NP	?	H 188 U 189
2	7-14-13	+ NP	— NP	+ P	?	H 190 U 191
3	7-15-13	+ NP	+ NP	+ NP	+ NP	H 192 U 193
4	7-15-13	+ P	+ NP	+ NP	+ NP	H 194 L 195
5	7-16-13		+ P	+ P	· NP	L 196 U 197
6	7-16-13	+ NP	+ NP	+ NP	+ NP	L 198
7	7-16-13	—	— NP	+ P	+ NP	H 199 L 200 U 201 C 202
8	7-16-13	+ P	+ P	+ NP	+ NP	H 203 L 204 U 205
9	7-16-13	+ NP	+ NP	+ NP	+ NP	L 206 U 207
10	7-17-13	+ NP	+ NP	+ NP	?	H 208 U 209
11	7-17-13		+ NP	+ NP	+ NP	L 210 U 211
12	7-18-13	+	+ NP	+ NP		L 212 U 213
13	7-21-13	+ NP	+ NP	+ NP		H 214 L 215 U 216
14	7-25-13	—	—	—	—	
15	7-28-13	—	+ P		—	L 217

LEGEND

+ = Bacterium pullorum detected
— = Bacterium pullorum not detected
P = signifies isolated in absolutely pure culture
NP = signifies culture showed some sign of contamination
H = culture isolated from heart
L = Culture recovered from liver
U = Culture isolated from unabsorbed yolk
C = Culture recovered from caeca. (signifying from either right or left)

The finger of the operator was placed under the *vena ulnaris*, between the ulnal and radial bones near the distal ends, and pressed until the vein by distention shows plainly. Then having sterilized the part, and using sterile fine scissors, a cut was made through the cutaneous tissue into the vein, making a short cut longitudinally. The blood will flow out in large drops, and can be easily collected into a test tube, and by using a pledget of cotton moistened with 1–40 carbolic acid the flow of blood can be quickly stopped, and then by placing a dry piece of cotton over the incision and closing the wing down tightly, in a few minutes the individual may be returned to the pen. Blood thus obtained is allowed to clot, and the serum is later drawn off as a straw-colored supernatant fluid. This is then diluted with carbolated salt solution to the usual stock dilution 1–20.

Making the Agglutination Test.

Small test tubes 4 inches long and ½-inch calibre were used. During some of our preliminary tests 3 c.c. test fluid was used as suggested by Jones,[1] but it was found after several sets had been tried out that 1.5 c.c. of the test fluid gave equally good results. The dilutions used most were 1–100, 1–200 and 1–500, but in some of the work test dilutions from 1–100 to 1–5,000 were used and made as follows: all sera were diluted 1–20, and then by a simple algebraic calculation the amount of diluted (1–20) serum necessary to add to 1.5 c.c. test fluid to make a desired dilution was determined. For example, 1.5 c.c. test fluid + .3 c.c. (1–20 serum) = dilution 1–100 desired. The following amounts of diluted 1–20 serum were added to 1.5 c.c. test fluid to make required dilutions: —

1– 100 = .3 c.c. diluted serum 1–20.
1– 200 = .15 c.c. diluted serum 1–20.
1– 300 = .099 c.c. diluted serum 1–20.
1– 400 = .075 c.c. diluted serum 1–20.
1– 500 = .06 c.c. diluted serum 1–20.
1– 800 = .037 c.c. diluted serum 1–20.
1–1,000 = .03 c.c. diluted serum 1–20.
1–1,200 = .025 c.c. diluted serum 1–20.
1–1,500 = .019 c.c. diluted serum 1–20.
1–1,800 = .016 c.c. diluted serum 1–20.
1–2,000 = .015 c.c. diluted serum 1–20.
1–2,500 = .012 c.c. diluted serum 1–20.
1–3,000 = .009 c.c. diluted serum 1–20.
1–4,000 = .007 c.c. diluted serum 1–20.
1–5,000 = .006 c.c. diluted serum 1–20.

Three sets of graduated pipettes were used, the first, a 5 c.c. graduated to $\frac{1}{10}$ c.c.; the second, graduated to $\frac{1}{100}$ c.c. The pipette graduated to $\frac{1}{100}$ c.c. was used to make dilutions up to 1–500, and for dilutions 1–500 to 1–5,000 one divided into $\frac{1}{1000}$ of c.c. was employed. After having made

[1] Jones, F. S.: "The value of the macroscopic agglutination test in detecting fowls that are harboring *Bact. pullorum*." Journal Medical Research, Vol. XXVII., No. 4; N. S., Vol. XXII., No. 4, pp. 485-495.

the desired dilution and thoroughly shaken each tube to afford a complete mixture of the agglutinative sera and *Bacterium pullorum* all was placed in the bacteriological incubator at 38° and readings made of the macroscopic agglutinative picture at the end of twenty-four, forty-eight and seventy-two hours. All tests were controlled, *i.e.*, test fluid and agglu ..ative sera.

A positive macroscopic agglutination reaction is evident when the formation of fine, flake-like masses settle to the bottom of the tube into uneven heaped-up masses at the bottom and sides, leaving the supernatant fluid clear. This reaction is usually very prompt, and with sera of marked potency it is very clear and definitely defined. Controls should always be kept for check of test fluid, and check of diluted serum in carbolated salt solution.

The test fluid used for our work at first was composed of the 6 tested strains of *Bacterium pullorum* preserved by 0.5 per cent. carbolic acid and kept on ice. The serum was used continuously until no positive reactions would result in a serum known to be positive, and from this it was possible to determine about how long a serum could be retained under proper conditions and be in an active state for use in making the test.

In tables 7 and 8 which follow can be seen the results of the macroscopic tests on the birds carried out by three different technicians working independently. The technician is denoted in the column of that legend as 1, 2 and 3. It is indeed interesting to note that the work of the three technicians checks very well, and from the summary of the work of each no difference ever arose as to whether a bird was or was not a reactor. Hens Nos. 267, 8, 1, 10, 6, 2096, 10, 18, 6, 2, 48, 7, 13, 53, 792, 714, 464 and 61 were all proven by all three technicians to be infected hens, having the agglutinin present, varying in its powers to cause agglutination of *Bacterium pullorum*. From tables 7 and 8 it can be seen that with the results in the agglutination work, especially the tests made with the blood drawn on July 19, and with the serum of hens Nos. 267, 2, 10, 2096, 5, 2, 48, 52, 53, 452, 792, 714 and 464, the serum reactions were consistent with the three technicians until the seventeenth or eighteenth days, when the reactions began to vary considerably. This is indeed an interesting feature in favor of the test, and it is possible, under better conditions of preservation, that it may be kept longer. After the hundreds of tests made in this laboratory it would be safe to state that properly preserved and cooled agglutinative sera may be retained in a good state for subsequent tests for as long as two weeks. On the other hand, a carefully prepared test fluid, made from newly incubated cultures of *Bact. pullorum*, and suspended in 0.85 per cent. physiological saline solution containing 0.5 per cent. phenol, if retained on ice will remain in good condition for making the tests even after two months.

In some instances a serum retained for three weeks, when used by one technician on the 6th of August reacted, and had lost its agglutinative powers on the 7th when used by another technician. At the beginning

TABLE 7.

AGGLUTINATION TESTS MADE WITH SERUM REMOVED JULY 3, 1913 AND TEST FLUID COMPOSED OF S_1 S_2 S_3 S_5 S_6 and S_7	AGGLUTINATION TESTS MADE WITH BLOOD SERUM REMOVED JULY 19, 1913 AND A TEST FLUID COMPOSED OF S_1 S_2 S_3 S_5 S_6 and S_7
DATE — TECHNICIAN — HOURS — DILUTIONS	DATE — TECHNICIAN — HOURS — DILUTIONS

Table 8.

AGGLUTINATION TESTS MADE WITH BLOOD SERUM REMOVED AUG 11, 1913.
AND A TEST FLUID COMPOSED OF S_1, S_2, S_3, S_5, S_6, AND S_7.

Hen	Date	Technician	Hours	Dilutions														
HEN 267	8/12	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	24	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	48	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	72	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	+	+			-		-								
	8/19	2	48	+	+			-		-								
	8/19	2	72	+	+			-		-								
	8/20	1	24	-	+			+	+	+								
	8/20	2	24	+	-			-		-								
	8/20	1	48															
	8/20	2	48	+	+			-		-								
	8/20	1	72	+	+			-	-	-								
	8/20	2	72	+	+			+		-								
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	-	-			-		-		-						
	8/25	2	72	+	+			-		-		-						
HEN 8	8/12		24															
	8/12		48															
	8/12		72															
	8/16	2	24	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
	8/16	2	48	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
	8/16	2	48	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
	8/19	2	24	+	+	+	+	+	+	+								
	8/19	2	48	+	+	+	+	+	+	+								
	8/19	2	72	+	+	+	+	+	+	+								
	8/20	1	24	+	+	+	+	+	+	+								
	8/20	2	24	+	+	+	+	+	+	+								
	8/20	1	48	+	+	+	+	+	+	+								
	8/20	2	48	+	+	+	+	+	+	+								
	8/20	1	72	+	+	+	+	+	+	+								
	8/20	2	72	+	+	+	+	+	+	+								
	8/25	2	24	+	+	+	+	+	+	+	+	+						
	8/25	2	48	+	+	+	+	+	+	+	+	+						
	8/25	2	72	+	+	+	+	+	+	+	+	+						
HEN 315	8/13	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/13	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/13	2	72															
	8/17	1	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	1	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	48	-	-	-	-	-	-	-	-	-						
	8/17	1	72	-	-	-	-	-	-	-	-	-						
	8/19	2	72	-	-	-	-	-	-	-	-	-						
	8/20	1	24	-	-	-	-	-	-	-	-	-						
	8/20	2	24	-	-	-	-	-	-	-	-	-						
	8/20	1	48															
	8/20	2	48	-	-	-	-	-	-	-	-	-						
	8/20	1	72															
	8/20	2	72	-	-	-	-	-	-	-	-	-						
	8/25	2	24	-	-	-	-	-	-	-	-	-						
	8/25	2	48	-	-	-	-	-	-	-	-	-						
	8/25	2	72	-	-	-	-	-	-	-	-	-						
HEN 1	8/12	2	24	-	-	-	-	-	-	-	-	-						
	8/12	2	48	-	-	-	-	-	-	-	-	-						
	8/12	2	72	+	+	+	+	+	+	+	-	-						
	8/17	1	24	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
	8/19	2	24															
	8/17	1	48	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	8/19	2	48	+	+	+	+	+	+	+								
	8/17	1	72															
	8/19	2	72	+	+	+	+	+	+	+								
	8/22	1	24	+	+			+	+	+								
	8/20	2	24	+	+			+										
	8/22	1	48	+	+			+	+	+								
	8/20	2	48	+	+			+		+								
	8/22	1	72															
	8/20	2	72	+	+			+		+								
	8/25	2	24	+	+			+		+								
	8/25	2	48	+	+			+		+		+						
	8/25	2	72	+	+			+		+		-	-	-				
HEN 49	8/12	2	24	-	-	-	-	-	-	-	-	-	-	-				
	8/12	2	48	-	-	-	-	-	-	-	-	-	-	-				
	8/12	2	72	-	-	-	-	-	-	-	-	-	-	-				
	8/16	2	24	-	-	-	-	-	-	-	-	-	-	-				
	8/16	2	48	-	-	-	-	-	-	-	-	-	-	-				
	8/16	2	72	-	-	-	-	-	-	-	-	-	-	-				
	8/19	2	24	-	-			-		-								
	8/19	2	48	-	-			-		-								
	8/19	2	72	-	-			-		-								
	8/20	1	24	-	-			-	-	-								
	8/20	2	24	-	-			-		-								
	8/20	1	48	-	-			-	-	-								
	8/20	2	48	-	-			-	-	-								
	8/20	1	72	-	-			-	-	-								
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-								
	8/25	2	48	-	-			-		-								
	8/25	2	72	-	-			-		-		-	-	-				
HEN 60	8/13	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/13	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/13	2	72															
	8/17	1	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	-	-			-	-	-								
	8/17	1	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	48	-	-			-		-								
	8/17	1	72															
	8/19	2	72	-	-			-		-								
	8/20	1	24	-	-			-	-	-								
	8/20	2	24	-	-			-		-								
	8/20	1	48	-	-			-	-	-								
	8/20	2	48	-	-			-	-	-								
	8/20	1	72	-	-			-	-	-								
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-								
	8/25	2	48	-	-			-		-								
	8/25	2	72	-	-			-		-								
HEN 22	8/12	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	-	-			-		-								
	8/19	2	48	-	-			-		-								
	8/19	2	72	-	-			-		-								
	8/20	1	24	-	-			-		-								
	8/20	2	24	-	-			-		-								
	8/20	1	48	-	-			-	-	-								
	8/20	2	48	-	-			-		-								
	8/20	1	72	-	-			-	-	-								
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	-	-			-		-		-	-	-				
	8/25	2	72	-	-			-		-		-	-	-				
HEN 10	8/12	2	24															
	8/12	2	48															
	8/12	2	72															
	8/16	2	24	+	+	+	+	-	-	-	-	-	-	-	-			
	8/16	2	48	+	+	+	+	+	-	-	-	-	-	-				
	8/16	2	72	+	+	+	+	+	-	-	-	-	-	-	-			
	8/19	2	24	+	+			+		+								
	8/19	2	48	+	+			+		+								
	8/19	2	72	+	+			+		+								
	8/20	1	24	+	+			+	+	+								
	8/20	2	24	+	+			+		-								
	8/20	1	48	+	+			+	+	+								
	8/20	2	48	+	+			+		+								
	8/20	1	72	+	+			+	+	+								
	8/20	2	72	+	+			+		+								
	8/25	2	24	+	+			+		+		+						
	8/25	2	48	+	+			+		+		+						
	8/25	2	72	+	+			+		+		+						
HEN 18	8/13	2	24															
	8/13	2	48															
	8/13	2	72															
	8/19	2	24	-	-			-		-								
	8/19	2	48	+	+			+		+								
	8/19	2	72	+	+			+		+								
	8/17	1	24	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-
	8/17	1	48	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-
	8/20	1	24	+	+			+		+								
	8/20	2	24	+	+			+		+								
	8/20	1	48															
	8/20	2	48	+	+			+		+								
	8/20	1	72	+	+			+	+	+								
	8/20	2	72	+	+			+		+								
	8/25	2	24	+	+			+		+		+						
	8/25	2	48	+	+			+		+		+	-	-				
	8/25	2	72	+	+			+		+		+	-	-				
HEN 77	8/12	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/17	1	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	-	-			-		-								
	8/17	1	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	48	-	-			-		-								
	8/17	1	72															
	8/19	2	72	-	-			-		-								
	8/20	1	24	-	-			-	-	-								
	8/20	2	24	-	-			-		-								
	8/20	1	48															
	8/20	2	48	-	-			-		-								
	8/20	1	72	-	-			-	-	-								
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	-	-			-		-		-						
	8/25	2	72	-	-			-		-		-						
HEN 6	8/13	2	24	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-
	8/13	2	48	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-
	8/13	2	72	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-
	8/16	2	24	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-
	8/16	2	48	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-
	8/16	2	72	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
	8/19	2	24	+	+			+		+								
	8/19	2	48	+	+			+		+								
	8/19	2	72	+	+			+		+								
	8/20	1	24	+	+			+	+	+								
	8/20	2	24	+	+			-		-								
	8/20	1	48	-	+			+	+	+								
	8/20	2	48	+	+			+		-								
	8/20	1	72	+	+													
	8/20	2	72	+	+			+		+								
	8/25	2	24	+	+			+		+		+						
	8/25	2	48	+	+			+		+		+	+					
	8/25	2	72	+	+			+		+		+	+					
HEN 20[illegible]	8/12	2	24	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	48	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	72	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	24	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	48	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	72	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	+	-	-		-	-	-								
	8/19	2	48	+	-	-		-	-	-								
	8/19	2	72	+	-	-		-	-	-								
	8/20	1	24	+	+			-	-	-								
	8/20	2	24	-	-			-		-								
	8/20	1	48	+	+			-	-	-								
	8/20	2	48	-	-			-	-	-								
	8/20	1	72	+	+			+	-	-								
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-		-	-	-				
	8/25	2	48	-	-			-		-		-	-	-				
	8/25	2	72	-	-			-										
HEN 2	8/16	2	24	+	+	+												
	8/16	2	48	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-
	8/16	2	72	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
	8/19	2	24	+	+			+		+								
	8/19	2	48	+	+			+		+								
	8/19	2	72	+	+			+		+								
	8/20	2	24	+	+			+		+								
	8/22	2	24	+	+			+	+	+								
	8/20	2	48	+	+			+		+								
	8/22	1	48	+	+			+	+	-								
	8/20	2	72	+	+			+		+								
	8/22	1	72															
	8/25	2	24	+	+			+		+		+						
	8/25	2	48	+	+			+		+		+						
	8/25	2	72	+	+			+		+		+	-	-				
HEN 4	8/13	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/13	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/17	1	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/17	1	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/17	1	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/20	1	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/20	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/20	1	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/20	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/20	1	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/20	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/25	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/25	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/25	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HEN 35	8/13	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/13	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/13	2	72															
	8/17	1	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	-	-			-		-								
	8/17	1	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	48	-	-			-		-								
	8/19	1	72															
	8/19	2	72	-	-			-		-	-	-						
	8/20	1	24	-	-			-	-	-								
	8/20	2	24	-	-			-		-								
	8/20	1	48	-														
	8/20	2	48	-	-			-		-								
	8/20	1	72	-	-			-	-	-								
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-								
	8/25	2	48	-	-			-		-								
	8/25	2	72	-	-			-		-								
HEN 48	8/16	2	24	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
	8/16	2	48	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
	8/16	2	72	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
	8/19	2	24	+	+			+		+								
	8/19	2	48	+	+			+		+								
	8/19	2	72	+	+			+		+								
	8/20	1	24	+	+			-	-	-								
	8/20	2	24	+	-			-	-	-								
	8/20	1	48	+	+			+	-	-								
	8/20	2	48	+	-			-		-								
	8/20	1	72	+	+			+	-	-								
	8/20	2	72	+	+			-		-								
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	-	-			-		-		-	-	-				
	8/25	2	72	-	-			-		-		-	-	-				
HEN 618	8/10	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/13	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/13	2	72															
	8/17	1	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	-	-	-		-		-								
	8/17	1	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	48	-	-			-										
	8/17	1	72															
	8/19	2	72	-	-			-		-								
	8/20	1	24	-	-			-	-	-								
	8/20	2	24	-	-			-		-								
	8/20	1	48															
	8/20	2	48	-	-			-		-								
	8/20	1	72	-	-			-	-	-								
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	-	-			-		-		-	-	-				
HEN 7	8/12	2	24	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-
	8/16	2	48	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-
	8/16	2	72	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
	8/19	2	24	+	+			+		+								
	8/19	2	48	+	+			+		+								
	8/19	2	72	+	+			+		+								
	8/20	1	24	+	+			+	+	+								
	8/20	2	24	+	+			+		+								
	8/20	1	48	+	+			+	+	+								
	8/20	2	48	+	+			+		+								
	8/20	1	72	+	+			+	+	+								
	8/20	2	72	+	+			+		+								
	8/25	2	24	+	+			+		+		+						
	8/25	2	48	+	+			+		+		+	-	-				
	8/25	2	72	+	+			+		+		+	-	-				
HEN 46	8/12	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	-	-			-		-								
	8/19	2	48	-	-			-		-								
	8/19	2	72	-	-			-		-								
	8/20	1	24	-	-			-	-	-								
	8/20	2	24	-	-			-		-								
	8/20	1	48	-	-			-	-	-								
	8/20	2	48	-	-			-	-	-								
	8/20	1	72	-	-			-	-	-								
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	-	-			-		-		-	-	-				
	8/25	2	72	-	-			-		-		-	-	-				
HEN 13	8/17	1	24	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
	8/19	2	24	+	+			+		+								
	8/17	1	48	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-
	8/19	2	48	+	+			+		+								
	8/17	1	72															
	8/19	2	72	+	+			+		+								
	8/20	2	24	+	+			-		-								
	8/20	1	24	+	+			+	+	+								
	8/20	1	48	+	+			+	+	+								
	8/20	2	48	+	+			+		+								
	8/20	1	72	+	+			+	+	+								
	8/20	2	72	+	+			+		+								
	8/25	2	24	+	+			+		+								
	8/25	2	48	+	+			+		+	+	+	-	-				
	8/25	2	72	+	+			+		+	+	+	-	-				
HEN 53	8/19	2	24	-	-			-		-								
	8/19	2	48	+	+			+		+								
	8/19	2	72	+	+			+		+								
	8/20	2	24															
	8/20	2	48	+	+			+		+								
	8/20	2	72	+	+			+		+								
	8/25	2	24	+	+			+		+	-	-						
	8/25	2	48	+	+			+		+		+						
	8/25	2	72	+	+			+		+		+						
HEN 792	8/20	1	24	+	+			+	-	-								
	8/20	2	24	-	-			-	-	-								
	8/20	1	48	+	+			+	+	+								
	8/20	2	48	-	-			-		-								
	8/20	1	72	+	+			-	-	-								
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	-	-			-		-		-	-	-				
	8/25	2	72	-	-			-		-		-	-	-				
HEN 714	8/16	2	24	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	48	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	72	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	+	-		-		-									
	8/19	2	48	+	+			-		-								
	8/19	2	72	+	+			-		-								
	8/20	1	24	+	+			+	-	-								
	8/20	2	24	+	-			-		-								
	8/20	1	48	+	+			+	-	-								
	8/20	2	48	+	+			-		-								
	8/20	1	72	+	+			-	-	-								
	8/20	2	72	+	+			+		-								
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	+	+			+		-		-	-	-				
	8/25	2	72	+	+			+		-		-	-	-				
HEN 34	8/12	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	-	-	-		-		-								
	8/19	2	48	-	-			-		-								
	8/19	2	72	-	-			-		-								
	8/20	1	24	-	-			-	-	-								
	8/20	2	24	-	-			-		-								
	8/20	1	48	-	-			-	-	-								
	8/20	2	48	-	-			-		-								
	8/20	1	72															
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	-	-			-		-		-	-	-				
	8/25	2	72	-	-			-		-		-	-	-				
HEN 464	8/16	2	24	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	48	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	72	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	+	+	-	-	-	-	-								
	8/19	2	48	+	+	-	-	-	-	-								
	8/19	2	72	+	+			-		-								
	8/20	2	24	+	+			-		-								
	8/22	1	24	+	+			+	+	+								
	8/20	2	48	+	+			-		-								
	8/22	1	48	+	+			+	+	+								
	8/20	2	72	+	+			-		-								
	8/22	1	72															
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	+	+			-		-		-	-	-				
	8/25	2	72	+	+			-		-		-	-	-				
HEN 61	8/17	1	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	+	+	-	-	-	-	-								
	8/17	1	48	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
	8/19	2	48	+	+	-	-	-	-	-	-	-						
	8/17	1	72															
	8/19	2	72	+	+			-		-	-	-						
	8/20	1	24															
	8/20	2	24	+	+			-		-								
	8/20	1	48															
	8/20	2	48	+	+			-		-	-	-						
	8/20	1	72	+	+			+	+	-								
	8/20	2	72	+	+			+		-	-	-						
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	-	-			-		-		-	-	-				
	8/25	2	72	-	-			-		-		-	-	-				

of this work, the serum was divided into three portions, to serve the technicians for independent work. The period of making tests for one technician often required more time to which the serum was submitted to laboratory temperature than that of another, and this in a way perhaps explains the keeping quality of one portion over another. However, one can see from the tests made that comparatively recently drawn sera carefully retained on ice yielded the best results.

Hens Nos. 315, 49, 60, 22, 77, 4, 35, 618, 46 and 34 never gave a positive reaction during this work, and the work of all three technicians checks in this respect. The serum of Nos. 2096, 52 and 464 gave varying reactions after long retention of serum, but no trouble was experienced by any of the workers in concluding that these birds either were harboring or had harbored *Bacterium pullorum*.

It may be stated here that under the conditions of the tests, if the test fluid is prepared uniformly, the test carefully carried out, the macroscopic agglutination test for detecting the virus of *Bacterium pullorum* has proven a good laboratory method as handled by three laboratory technicians in this laboratory during the past summer.

The Influence of Test Fluids of Varying Composition (Monovalent and Polyvalent Test Fluids).

For these tests an experiment was planned in which the serum was used, drawn on the 19th of July. The test fluid was composed of equal quantities of the different strains of *Bacterium pullorum* used throughout this work. In the first experiment or test a test fluid containing S_1 was used; in the second, a test fluid containing S_2; in a third, a test fluid containing equal quantities S_1 and S_2; in a fourth, a test fluid containing equal quantities S_1, S_2 and S_3; in a fifth, a test fluid containing equal quantities S_1, S_2 and S_7; in a sixth, a test fluid containing S_1, S_2, S_3 and S_5; in a seventh, a test fluid containing S_1, S_2, S_3, S_5 and S_6; and in an eighth, a test fluid containing S_1, S_2, S_3, S_5, S_6 and S_7. Various dilutions of the serum were used, the dilutions being made as before. In most cases readings were made after twenty-four, forty-eight and seventy-two hours' incubation.

An analysis of Table 9 shows that the serum from all hens which had previously agglutinated gave consistent positive results in all the sera. Sera from hens Nos. 2096, 452, 792 and 5 appeared to give better results with a test fluid containing several strains of the organism. Although some of the positive reactors showed good reactions with a monovalent test fluid, yet from the data at hand it may be stated as justified that a test fluid containing several different strains is best suited, under most conditions, in laboratory routine for making the test. Here it should be noted that none of the birds previously tested and found negative reacted when their serum was mixed with the test fluids of the various compositions.

The birds Nos. 58, 59, 62 and 63 were cocks. Of these, 59, 62 and 63 gave questionable reactions, and 58 gave a very weak or slight reaction of a positive nature. This is interesting, and it will require further study with this blood and work in connection with the autopsies of such birds to determine if the testicles of such individuals harbor the organism. The reactions with these birds were always very slight and questionable, and hardly comparable with the clearcut reactions exhibited when the blood serum from infected hens was used.

Comparison of Results of Macroscopic Agglutination Tests with Egg Analysis.

From the egg record table it can be seen that *Bacterium pullorum* was isolated 32 times from 619 eggs, and the individuals harboring such organisms, determined by eggs laid in July, were hen No. 10 on the 30th; hen No. 18 on the 26th; hen No. 6 on the 16th, 17th and 19th; hen No. 5 on the 30th; hen No. 2 on the 26th and 30th; hen No. 52 on the 21st and 23d; hen No. 13 on the 22d and 26th; hen No. 792 on the 23d, 25th and 30th; hen No. 714 on the 27th; and in August, besides these hens, hen No. 8 laid an egg containing *Bacterium pullorum* on the 18th; hen No. 1 on the 15th; hen No. 2096 on the 12th; hen No. 7 on the 4th and 13th; and in September, hen No. 48 on the 6th; hen No. 464 on the 13th and the 16th. Hen No. 452 died before an egg was laid which contained the organism, but at autopsy, when ova from this individual were crushed and inoculated into sterile bouillon and put in incubator at 38° C., the organism was detected later on the agar streaks. Hen No. 267 had previously been found to be infected by an egg test. Serum from all these hens caused agglutination of *Bacterium pullorum* test fluids, the results of three technicians being in agreement. The organism was not isolated from the ovarian tissue of hen Nos. 53 or 61, although both these hen's blood serum caused very active agglutination. This may suggest that the active infection had passed, and the agglutination test showed the results of the past active infection. On the other hand, hens Nos. 315, 49, 60, 22, 77, 4, 35, 618, 312, 46 and 34 never exhibited the organism in their eggs, nor did blood serum from these individuals cause agglutination of *Bact. pullorum*.

Post-mortem Findings of Some Reactors and Non-reactors.

After Oct. 1, 1913, hens Nos. 10, 5, 52, 1, 792, 464, 6 and 13, as reactors, were killed and the ovaries examined for the presence of *Bacterium pullorum*. All the reactors were not killed because it was desired to make further studies with the agglutinins. At the present time hens containing active agglutinative sera are retained at the laboratory under constant observation. Hen No. 10 at autopsy revealed a pathological ovary containing several retention cysts. *Bacterium pullorum* was isolated from this material by direct inoculation. Hen No. 52 at autopsy showed an ovary with retention cysts, and from material crushed in sterile bouillon *B. pullorum* was detected on all tubes streaked from such material. Then hens Nos. 1, 5, 6, 792, 464 and 13 were autopsied. All ovaries from these

TABLE 9.

AGGLUTINATION TESTS MADE WITH TEST FLUIDS OF DIFFERENT COMPOSITIONS

$S_1 - S_1 S_2 S_3 S_5 S_6 S_7$

Test fluid contains S_1

Hen No	Hrs				
267	24	+	-	-	-
	48	+	+	-	-
	72	+	+	-	-
8	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
315	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
1	24	-	-	-	-
	48	+	+	+	+
	72	+	+	+	+
49	24	-	-	-	-
	48	-	-	-	-
	72	+	-	-	-
60	24	-	-	-	-
	48	+	-	-	-
	72	+	-	-	-
22	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
10	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
18	24	-	-	-	-
	48	-	+	+	+
	72	+	+	+	+
77	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
6	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
2096	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
2	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
4	24	+	+	-	-
	48	+	+	-	-
	72	+	+	-	-
35	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
48	24	-	-	-	-
	48	+	-	-	-
	72	+	+	+	+
618	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
7	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
46	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
13	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
53	24	-	-	-	-
	48	+	+	+	+
	72	+	+	+	+
792	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
714	24	+	-	-	-
	48	+	+	-	-
	72	+	+	-	-
34	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
464	24	+	+	-	-
	48	+	+	-	-
	72	+	+	-	-
61	24	+	+	-	-
	48	+	+	-	-
	72	+	+	-	-
58	24	-	-	-	-
	48	+	-	-	-
	72	+	-	-	-
59	48	-	-	-	-
	24	-	-	-	-
	72	-	-	-	-
62	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
63	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-

Test fluid contains S_2

Hen No	Hrs						
267	24				-	-	-
	48				-	-	-
	72				-	-	-
8	24				+	+	+
	48				+	+	+
	72				+	+	+
315	24		-	-			
	48		-	-			
	72		-	-			
1	24				+	-	-
	48				+	+	-
	72				+	+	+
60	24	-	-	-			
	48	-	-	-			
	72	-	-	-			
10	24				-	-	-
	48				-	-	-
	72				+	-	-
18	24				+	+	-
	48				+	+	+
	72				+	+	-
77	24	-	-	-			
	48	-	-	-			
	72	-	-	-			
6	24				+	-	-
	48				+	-	-
	72				+	+	-
2096	24				-	-	-
	48				-	-	-
	72				-	-	-
5	24		-	-			
	48		-	-			
	72		+	+			
2	24	+	+	+	-	-	-
	48	+	+	+	-	-	-
	72	+	+	+	-	-	-
4	24	-	-	-			
	48	-	-	-			
	72	-	-	-			
35	24	-	-	-			
	48	-	-	-			
	72	-	-	-			
48	24		-	-			
	48		-	-			
	72		-	-			
618	24	-	-	-			
	48	-	-	-			
	72	-	-	-			
7	24	+	+	+	-	-	-
	48	+	+	+	+	-	-
	72	+	+	+	+	+	-
46	24		-	-			
	48		-	-			
	72		-	-			
52	24				-	-	-
	48				-	-	-
	72				-	-	-
13	24	+	+	+	+		
	48	+	+	+	+		
	72	+	+	+	+		
53	24	+	+	+	-	-	-
	48	+	+	+	-	-	-
	72	+	+	+	-	-	-
452	24	+	+	-	-	-	-
	48	+	+	-	-	-	-
	72	+	+	-	-	-	-
792	24				-	-	-
	48				-	-	-
	72				-	-	-
714	24		-	-			
	48		-	-			
	72		-	-			
34	24	-	-	-			
	48	-	-	-			
	72	-	-	-			
464	24	+	+		-	-	-
	48	+	+		-	-	-
	72	+	+		-	-	-

Test fluid contains $S_1 + S_2$

Hen No	Hrs															
267	24	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
8	24	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
	48	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
	72	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
315	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	24	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
	48	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
49	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	24	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-
	48	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
	72	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
18	24	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-
	48	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-
77	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	24	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-
	48	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-
	72	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
2096	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	24	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-
	48	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
	72	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
4	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
35	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
618	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	24	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-
	48	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-
	72	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
46	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	24	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-
	48	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-
792	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
714	24	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
464	24	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
61	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
58	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
59	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
62	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
63	24	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
	48	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-

Test fluid contains $S_1 + S_2 + S_3$

Hen No	Hrs					
267	24	+	+			
	72	+	+			
8	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
315	24	-	-	-	-	-
1	24	+	+	+	+	+
	48	+	+	+	+	+
49	24	-	-	-	-	-
	48	+	-	-	-	-
	72	+	+	+	+	-
60	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
22	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
10	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
18	24	+	+	+	+	+
	72	+	+	+	+	+
77	24	-	-	-	-	-
	72	-	-	-	-	-
6	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
2096	24	+	+	-	-	-
	48	+	+	+	-	-
	72	+	+	+	-	-
2	24	+	+	+	+	-
	48	+	+	+	+	-
4	24	+	+	+	-	-
	72	+	+	+	-	-
35	24	-	-	-	-	-
	72	-	-	-	-	-
48	24	+	+	-	-	-
	48	+	+	+	-	-
	72	+	+	+	-	-
618	24	+	-	-	-	-
	72	-	-	-	-	-
7	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
46	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
13	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
13	24	+	+	+	+	+
	48	+	+	+	+	+
792	24	+	+	+	-	-
	48	+	+	+	+	+
	72	+	+	-	-	-
714	24	+	+	+	-	-
	48	+	+	+	-	-
	72	+	+	-	-	-
34	24	-	-	-	-	-
	48	-	-	-	-	-
464	24	+	+	+	+	+
	48	+	+	+	+	+
61	72	+	+	+	+	-
58	24	+	+	-	-	-
	48	+	+	-	-	-
	72	+	+	-	-	-
59	24	-	-	-	-	-
	48	+?	-	-	-	-
	72	+?	-	-	-	-
62	24	+?	+?	+?	+?	-
	48	+?	+?	+?	+?	+
	72	+?	+?	+?	+?	-
63	24	+?	+?	+?	+?	-
	48	+?	+?	+?	+?	-
	72	+?	+?	+?	+?	-

Test fluid contains $S_1 + S_2 + S_7$

Hen No	Hrs															
315	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
618	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
46	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Test fluid contains $S_1 + S_2 + S_3 + S_5$

Hen No	Hrs				
267	24	+	-	-	-
	48	+	+	-	-
	72	+	+	+	-
8	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
315	24	-	-	-	-
	48	+	-	-	-
	72	+	-	-	-
1	24	+	+	+	-
	48	+	+	+	+
	72	+	+	+	+
49	24	-	-	-	-
	48	+	-	-	-
	72	+	-	-	-
60	24	-	-	-	-
	48	-	-	-	-
	72	+	-	-	-
22	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
10	24	+	+	+	-
	48	+	+	+	+
	72	+	+	+	+
18	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
77	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
6	24	+	+	-	-
	48	+	+	+	-
	72	+	+	+	+
2096	24	-	-	-	-
	48	-	-	-	-
	72	+	+	+	+
2	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
4	24	+	+	-	-
	48	+	+	-	-
	72	+	+	-	-
35	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
48	24	-	-	-	-
	48	+	-	-	-
	72	+	+	-	-
618	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
7	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
46	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
19	24	+	+	-	-
	48	+	+	+	+
	72	+	+	+	+
53	24	-	-	-	-
	48	+	+	+	+
	72	+	+	+	+
792	24	-	-	-	-
	48	-	-	-	-
	72	+	+	+	-
714	24	+	-	-	-
	48	+	+	-	-
	72	+	+	+	-
34	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
464	24	+	+	-	-
	48	+	+	-	-
	72	+	+	-	-
61	24	+	+	-	-
	48	+	+	-	-
	72	+	+	+	-
58	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
59	24	+?	-	-	-
	48	+?	-	-	-
	72	+?	-	-	-
62	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
63	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-

Test fluid contains $S_1 + S_2 + S_3 + S_5 + S_6$

Hen No	Hrs					
267	24	+	-	-		
	48	+	+	-		
	72	+	+	-		
8	24	-	-	-		
	48	+	+	+		
	72	+	+	+		
315	24	-	-	-	-	-
	48	+	-	-	-	-
	72	+	-	-	-	-
1	24	+	+	-		
	48	+	+	+		
	72	+	+	+		
49	24	-	-	-		
	48	-	-	-		
	72	-	-	-		
60	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
22	24	-	-	-		
	48	+	+	-		
	72	+	+	-		
10	24	+	-	-		
	48	+	-	-		
	72	+	+	+		
18	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
77	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
6	24	-	-	-		
	48	+	+	+		
	72	+	+	+		
2096	24	+	+	+		
	48	+	+	+		
	72	+	+	+		
5	24	-	-	-		
	48	+	-	-		
	72	+	+	-		
2	24	-	-	-		
	48	-	-	-		
	72	-	-	-		
4	24	+	+	+	-	-
	48	+	+	+	-	-
	72	+	+	+	-	-
35	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
48	24	-	-	-		
	48	-	-	-		
	72	-	-	-		
618	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
7	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
46	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
13	24	+	+	+		
	48	+	+	+		
	72	+	+	+		
53	24	+	+	+	+	-
	48	+	+	+	+	+
	72	+	+	+	+	+
452	24	-	-	-		
	48	+	-	-		
	72	+	-	-		
792	24	-	-	-		
	48	-	-	-		
	72	+	+	-		
714	24	+	+	-		
	48	+	+	-		
	72	+	+	-		
34	24	-	-	-		
	48	-	-	-		
	72	-	-	-		
464	24	+	+	+		
	48	+	+	+		
	72	+	+	+		
61	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
59	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
63	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-

Hen No	Hrs					
267	24	-	-	-	-	-
	48	-	-	-	-	-
	72	+	+	-	-	-
8	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
1	24	+	+	+	+	-
	48	+	+	+	+	+
	72	+	+	+	+	+
49	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
22	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
10	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
6	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
2096	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
2	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
48	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
46	24	-	-	-		
	48	-	-	-		
	72	-	-	-		
13	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
792	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
714	24	-	-	-	-	-
	48	+	+	+	-	-
	72	+	+	+	-	-
34	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
464	24	-	-	-	-	-
	48	+	+	-	-	-
	72	+	+	-	-	-
58	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
62	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-

Test fluid contains $S_1 + S_2 + S_3 + S_5 + S_6 + S_7$

Hen No	Hrs			
267	24	+	+	-
	24	+	+	-
	48	+	+	+
	48	+	+	+
8	24	-	-	-
	24	-	-	-
	48	+	+	+
	48	+	+	+
315	24	-	-	-
	24	-	-	-
	48	-	-	-
	48	-	-	-
1	24	+	+	-
	24	+	-	-
	48	+	+	+
	48	+	+	-
49	24		-	-
	24	-	-	-
60	24	-	-	-
	24	-	-	-
	48	-	-	-
22	24	-	-	-
	24	-	-	-
10	24	+	+	-
	24	+	+	-
	48	+	+	+
	48	+	+	+
18	24	+	+	+
	24	+	+	+
77	24	-	-	-
	24	-	-	-
	48	-	-	-
6	24	-	-	-
	24	-	-	-
	48	+	+	-
2096	24	+	+	-
	24	+	+	-
	48	+	+	-
	48	+	+	-
5	24	-	-	-
	24	-	-	-
2	24	-	-	-
	24	-	-	-
	48	-	-	-
	48	-	-	-
4	24	-	-	-
	24	-	-	-
	48	-	-	-
35	24	-	-	-
	24	-	-	-
	48	-	-	-
48	24	-	-	-
	24	-	-	-
	48	-	-	-
	48	-	-	-
618	24	-	-	-
	24	-	-	-
	48	-	-	-
	48	-	-	-
7	24	-	-	-
	24	-	-	-
	48	+	+	+
	48	+	+	+
46	24	-	-	-
	24	-	-	-
	48	-	-	-
	48	+	-	-
52	24			
	24	-	-	-
	48	-	-	-
13	24	-	-	-
	24	-	-	-
	48	-	-	-
	48	+	-	-
53	24	+	-	-
	24	+	-	-
	48	+	+	-
452	24	+	+	+
	24	+	+	-
	48	+	+	+
	48	+	+	+
792	24	+	+	-
	48	+	+	-
	24	+	+	+
	48	+	+	+
464	24	+	+	-
	24	+	+	+
	48	+	+	+

Hen No	Hrs			
267	72	+	+	+
	72	+	+	+
	24	-	-	-
	24	-	-	-
8	72	+	+	+
	72	+	+	+
	24	+	+	+
	24	+	+	+
315	72	-	-	-
	72	-	-	-
1	72	+	+	+
	72	+	+	+
	24	+	+	-
	24	+	+	+
49	48	-	-	-
	48	-	-	-
60	48	-	-	-
	72	-	-	-
	72	-	-	-
22	48	-	-	-
	48	-	-	-
10	72	+	+	+
	72	+	+	+
	24	+	-	-
	24	+	+	+
18	48	+	+	+
	48	+	+	+
	72	+	+	+
77	48	-	-	-
	72	-	-	-
	72	-	-	-
6	48	+	+	+
	72	+	+	+
	72	+	+	+
2096	72	+	+	+
	72	+	+	+
	24	+	+	-
	24	-	-	-
5	48	-	-	-
	48	-	-	-
	72	-	-	-
2	72	+	+	+
	72	+	+	+
	24	+	+	-
	24	+	+	-
4	48	-	-	-
	72	-	-	-
	72	-	-	-
35	48	-	-	-
	72	-	-	-
	72			
48	72	+	+	+
	72	+	+	+
	24	-	-	-
	24	-	-	-
618	72	-	-	-
	24	-	-	-
	48	-	-	-
	72	-	-	-
7	72	+	+	+
	72	+	+	+
	24	+	+	-
	24			
46	72	+	-	-
	24	-	-	-
	24	-	-	-
	48	-	-	-
52	48	-	-	-
	72	+	+	-
	72	-	-	-
13	72	+	+	-
	72	+	+	-
	24	+	+	-
	24	-	-	-
53	48	+	+	+
	72	+	+	+
	72	+	+	+
452	72	+	+	+
	72	+	+	+
	24	-	-	-
	24	-	-	-
792	72	+	+	-
	72	+	+	+
	24	-	-	-
	24	-	-	-
464	48	+	+	+
	72	+	+	+
	72	+	+	-

Hen No	Hrs			
267	48	+	+	+
	48	-	-	-
	72	+	+	-
8	48	+	+	+
	48	+	+	+
	72	+	+	+
315	24	-	-	-
	48	-	-	-
	72	+	+	-
1	48	+	+	+
	48	+	+	+
	72	+	+	+
	24	+	+	+
49	72	-	-	-
	24	-	-	-
60	24	-	-	-
	48	-	-	-
	72	-	-	-
22	72	+	+	-
	24	-	-	-
10	48	+	+	+
	48	+	+	+
	72	+	+	+
18	24	+	+	+
	24	-	-	-
	48	+	+	+
77	24	-	-	-
	48	-	-	-
	72	-	-	-
6	24	+	+	-
	24	+	+	-
	48	+	+	+
2096	48	+	+	-
	48	+	+	-
	72	+	+	-
	72	+	+	-
5	24	+	-	-
	24	-	-	-
	48	+	+	-
2	48	+	-	-
	48	+	+	+
	72	+	+	+
	72	+	+	+
4	24	-	-	-
	48	-	-	-
	72	-	-	-
35	24	-	-	-
	24	+	+	-
	48	-	-	-
48	48	-	-	-
	48	+	-	-
	72	+	+	-
	72	+	+	-
618	24	-	-	-
	48	-	-	-
	72	-	-	-
7	48	+	+	+
	48	+	+	+
	72	+	+	+
	72	+	+	+
46	48	-	-	-
	72	-	-	-
	72	-	-	-
52	24	+	+	-
	48	+	+	-
	72	+	+	+
13	48	+	+	+
	48	+	+	-
	72	+	+	-
	72	+	+	-
53	24	+	+	-
	24	+	-	-
	48	+	+	+
452	48	-	-	-
	48	-	-	-
	72	+	-	-
	72	+	+	+
792	48	-	-	-
	48	-	-	-
	72	+	-	-
	72	+	+	-
464	24	+	+	-
	24	+	-	-
	48	+	+	-

Hen No	Hrs			
267	24	-	-	-
	24	+	+	-
	48	+	+	-
	48	+	+	-
8	24	+	+	+
	24	+	+	+
	48	+	+	+
	48	+	+	+
315	24	-	-	-
	48	-	-	-
	72	-	-	-
1	24	+	+	+
	48	+	+	+
	48	+	+	+
	72	+	+	+
49	48	-	-	-
	72	-	-	-
60	24	-	-	-
	48	-	-	-
	72	-	-	-
22	48	-	-	-
	72	-	-	-
10	24	+	+	+
	24	+	+	+
	48	+	+	+
	48	+	+	+
18	48	+	+	+
	72	+	+	+
	72	+	+	+
77	24	-	-	-
	48	-	-	-
	72	-	-	-
6	48	+	+	+
	48	-	+	+
	72	+	+	+
2096	24	-	-	-
	24	+	+	+
	48	-	-	-
	48	+	+	+
5	48	-	-	-
	72	+	+	-
	72	-	-	-
2	24	+	+	-
	24	+	+	-
	48	+	+	+
	48	+	+	+
4	24	-	-	-
	48	-	-	-
	72	-	-	-
35	48	-	-	-
	72	+	+	-
	72	-	-	-
48	24	-	-	-
	24	-	-	-
	48	+	+	+
	48	-	-	-
618	24	-	-	-
	48	-	-	-
	72	-	-	-
7	24	+	+	+
	24	+	-	-
	48	+	+	+
	48	+	+	-
46	24	+	-	-
	48	-	-	-
	72	+	-	-
52	24	-	-	-
	48	-	-	-
	72	-	-	-
13	24	+	-	-
	24	+	+	+
	48	+	+	+
	48	+	+	-
53	48	+	+	+
	72	+	+	+
	72	+	+	+
452	24	-	-	-
	24	+	+	+
	48	+	+	+
	48	+	+	-
792	24	-	-	-
	24	-	-	-
	48	+	+	+
	48	-	-	-
464	48	+	-	-
	72	+	+	-
	72	+	+	-

Hen No	Hrs			
267	72	+	+	-
	24	-	-	-
	48	+	+	-
	72	+	+	-
8	72	+	+	+
	24	+	+	+
	48	+	+	+
	72	+	+	+
315	24	-	-	-
	24	-	-	-
	24	-	-	-
1	72	+	+	+
	24	+	-	-
	48	+	+	+
	72	+	+	+
60	24	-	-	-
	24	-	-	-
	24	-	-	-
10	72	+	+	+
	72	+	+	+
	24	-	-	-
	48	+	-	-
18	24	+	-	-
	48	+	+	-
	72	+	+	+
77	24	-	-	-
	24	-	-	-
	24	-	-	-
6	24	+	+	-
	48	-	-	-
	72	+	-	-
2096	72	+	+	-
	24	-	-	-
	48	-	-	-
	72	-	-	-
5	24	-	-	-
	48	-	-	-
	72	+	+	-
2	72	+	+	-
	24	-	-	-
	48	+	-	-
	72	+	+	+
4	24	-	-	-
	24	-	-	-
	24	-	-	-
35	24	-	-	-
	48	-	-	-
	72	-	-	-
48	72	+	-	-
	24	+	+	-
	48	+	+	-
	72	+	+	-
618	24	-	-	-
	48	-	-	-
	72	-	-	-
7	72	+	+	+
	24			
	48	+	+	+
	72	+	+	+
46	24	-	-	-
	48	-	-	-
	72	-	-	-
52	24	-	-	-
	24	-	-	-
	24	-	-	-
13	72	+	+	+
	24	+	+	-
	48	+	+	+
	72	+	+	-
53	24	+		-
	48	+	+	-
	72	+	+	-
452	72	+	+	-
	24	+	+	-
	48	+	+	-
	72	+	-	-
792	72	+	-	-
	24	-	-	-
	48	-	-	-
	72	-	-	-
464	24	+	+	-
	24	+	+	+
	48	+	+	+

Hen No	Hrs			
267	24	-	-	-
	24	-	-	-
	24	-	-	-
8	24	-	-	-
	24	-	-	-
	24	-	-	-
315	48	-	-	-
	48	-	-	-
	48	-	-	-
1	24	+	-	-
	24	+	-	-
	24	-	-	-
60	48	-	-	-
	48	-	-	-
	48	-	-	-
10	72	+	+	+
	24	-	-	-
	24	-	-	-
	24	-	-	-
18	24	+	-	-
	24	+	+	-
	24	+	-	-
77	48	-	-	-
	48	-	-	-
	48	-	-	-
0	24	+	+	+
	24	+	+	+
	48	+	+	+
2096	24	-	-	-
	24	-	-	-
	24	-	-	-
5	24	+	-	-
	48	+	+	-
	72	-	-	-
	24	-	-	-
2	24	+	+	-
	24	+	+	-
	24	+	+	+
4	48	-	-	-
	48	-	-	-
	48	-	-	-
35	24	-	-	-
	24	-	-	-
	24	-	-	-
48	24	+	+	-
	24	+	+	-
	24	+	+	-
618	24	-	-	-
	24	-	-	-
	24	-	-	-
7	24	+	+	+
	24	+	-	+
	24	+	+	+
46	24	-	-	-
	24	-	-	-
	24	-	-	-
52	48	-	-	-
	48	-	-	-
	48	-	-	-
13	24	+	+	-
	24	+	+	-
	24	+	+	-
53	24	+	-	-
	24	+	+	-
	24	+	+	-
452	24	+	+	-
	24	+	+	-
	24	+	+	-
792	24	-	-	-
	24	-	-	-
	24	-	-	-
464	48	+	+	+
	72	+	+	+
	24	-	-	-

Hen No	Hrs			
267	48	-	-	-
	48	-	-	-
	48	-	-	-
8	48	+	+	+
	48	+	+	-
	48	-	-	-
315	72	-	-	-
	72	-	-	-
	72	-	-	-
1	48	+	-	-
	48	+	+	-
	48	+	+	-
60	72	-	-	-
	72	-	-	-
	72	-	-	-
10	48	-	-	-
	48	-	-	-
	48	-	-	-
18	48	-	-	-
	48	+	+	-
	48	+	-	-
77	72	-	-	-
	72	-	-	-
	72	-	-	-
6	48	+	+	+
	72	+	+	+
	72	+	+	+
2096	48	-	-	-
	48	-	-	-
	48	-	-	-
5	24	-	-	-
	24	-	-	-
	48	-	-	-
	48	-	-	-
2	48	+	+	-
	48	+	+	-
	48	+	+	-
4	72	-	-	-
	72	-	-	-
	72	-	-	-
35	48	+	+	-
	48	-	-	-
	48	-	-	-
48	48	+	+	-
	48	+	-	-
	48	+	+	+
618	48	-	-	-
	48	-	-	-
	48	-	-	-
7	48	+	+	+
	48	+	+	+
	48	+	+	+
46	48	-	-	-
	48	-	-	-
	48	-	-	-
52	72	-	-	-
	72	-	-	-
	72	-	-	-
13	48	+	+	-
	48	+	+	-
	48	+	+	-
53	48	+	+	-
	48	+	+	-
	48	+	+	-
452	48	+	+	-
	48	+	-	-
	48	+	+	-
792	48	-	-	-
	48	-	-	-
	48	-	-	-
464	24	-	-	-
	72	+	-	-
	24	-	-	-

Hen No	Hrs			
267	72	-	-	-
	72	-	-	-
	72	-	-	-
8	72	+	+	-
	72	-	-	-
	72	-	-	-
1	72	+	+	-
	72	+	+	+
	72	+	+	-
10	72	-	-	-
	72	-	-	-
	72	-	-	-
18	72	-	-	-
	72	+	+	-
	72	+	-	-
2096	72	-	-	-
	72	-	-	-
	72	-	-	-
5	48	-	-	-
	72	-	-	-
	72	-	-	-
	72	-	-	-
2	72	+	+	+
	72	+	+	+
	72	+	+	+
35	72	-	-	-
	72	-	-	-
	72	-	-	-
48	72	+	+	-
	72	+	+	-
	72	+	+	+
618	72	-	-	-
	72	-	-	-
	72	-	-	-
7	72	+	+	+
	72	+	+	+
	72	+	+	+
46	72	-	-	-
	72	-	-	-
	72	-	-	-
13	72	+	+	-
	72	+	+	-
	72	+	-	-
53	72	+	+	+
	72	+	+	+
	72	+	+	+
452	72	+	+	-
	72	+	+	-
	72	+	+	-
792	72	-	-	-
	72	-	-	-
	72	-	-	-
464	24	-	-	-
	48	+	-	-
	48	+	-	-

hens were cystic, exhibiting cysts of varying sizes, and the color was from normal yellow to grayish green. Hen No. 5 showed the least pathological condition of the ovaries. Many ova here were quite normal, and exhibited the usual high-colored picture so characteristic of a healthy ovary. Material from hens Nos. 1, 5, 6, 792, 464, 13 and 452 (previously examined) yielded cultures of *Bacterium pullorum*. Hens Nos. 34, 315, 49, 312, 60, 22, 77, 4, 35, 618 and 46, whose sera had never agglutinated, and in whose eggs *Bacterium pullorum* had not been found, were autopsied. All ova were normal except that of 77, which showed grossly congestion. More than 100 agar tubes were streaked from these ovaries and from materials crushed in sterile bouillon and incubated, and all gave negative results for *B. pullorum*. Hen No. 53, a positive reactor, and hen No. 46, a non-reactor, were killed accidentally, so data on ovaries from these hens were not obtained. The pathological findings of the birds that agglutinated correspond well with those previously described, and especially with previous observations by the author in 1910,[1] and also substantiate the work of Jones.[2] All ovaries from these birds exhibited one or more retention cysts and several irregular lobulated cysts, and the color varied from shades of yellow to green.

Specificity of Bacterium Pullorum Agglutinin.

The first recognition of the agglutination reaction as a separate function of immune sera was by Gruber and Durham.[3] From the first these investigators had claimed specificity for the agglutination reaction, and for this reason it was utilized by Widal for the diagnosis of typhoid fever. Even by early workers it was observed that serum of animals immunized against one micro-organism would often agglutinate to a much less marked degree other closely related species. The serum of a typhoid-immune animal may agglutinate the typhoid bacillus in dilutions of 1–1,000 and higher, and *B. coli* in dilutions as high as 1–200. The normal agglutinative power of *B. coli* does not exceed 1–20. Therefore the specificity of the reaction for practical purposes is not destroyed if the proper dilutions are carried out, the degree or amount of agglutinin formation being always far higher for the specific organism causing the formation of the agglutinin than for closely related species.

After carrying out 300 tests with normal sera from birds known to have no infection, we feel justified in stating that in some instances we were able to obtain slight agglutinative reactions in dilutions of 1–25, but in no instance was there ever exhibited the slightest sign of the agglutination of *Bacterium pullorum* when dilutions 1–100 of normal serum from non-

[1] Gage, Geo. Edward: "Notes on ovarian infection with *Bacterium pullorum* (Rettger) in the domestic fowl." Journal Medical Research, Vol. XXIV., No. 3; N. S., Vol. XIX., No. 3; June, 1911, pp. 491–496.

[2] Jones, F. S.: "The value of the macroscopic agglutination test in detecting fowls that are harboring *Bact. pullorum*." Journal Medical Research, Vol. XXVII., No. 4; N. S., Vol. XXII., No. 4, pp. 485-495.

[3] Gruber and Durham: Münch med. Woch, 1906.

infected individuals were used. For this reason, in the work carried out here, the lowest diagnostic dilution was 1–100. If reaction resulted with *Bacterium pullorum* in this dilution it was considered positive, and the individual rated as a reactor.

Since *Bacterium pullorum* has been placed in the *B. coli-typhi-dysenteræ* group of bacteria it was considered of interest to determine if *Bacterium pullorum* agglutinative sera were specific for *Bacterium pullorum*. For these tests the best known members of the *B. coli-typhi* group of bacteria were used. The sera from two hens harboring the organism was drawn and diluted with carbolated salt solution 1–20. Test fluids of uniform turbidity were prepared, as previously for *Bacterium pullorum*, of the following organisms: *B. coli communis, B. coli communior, B. icteroides, B. enteritidis, B. paratyphi A., B. paratyphi B., B. typhi abdominalis, B. Fowl cholera, B. cloacæ, B. lactis aerogenes,* and lastly a test fluid of *Bacterium pullorum*. Complete sets of test tubes were made for each, and to each was added the amount of *Bacterium pullorum* agglutinative sera to give the required dilution. The dilutions in all sets were from 1–100 to 1–5,000, the principal dilutions between these ranges were in the following order: 1–100, 1–200, 1–300, 1–400, 1–500, 1–800, 1–1,000, 1–1,200, 1–1,500, 1–1,800, 1–2,000, 1–2,500, 1–3,000, 1–4,000 and 1–5,000.

By observation of Table 10 it can be seen that the *Bacterium pullorum* agglutinative sera caused agglutination only when put in contact with *Bacterium pullorum*. Not the slightest agglutination occurred in any of the tubes containing test fluid other than *Bacterium pullorum*. From this data it would seem that the *Bacterium pullorum* agglutinin is highly specific, and therefore is of great diagnostic value in all work in which the organism must be determined.

Agglutinins obtained by the Immunization of Rabbits against Bacterium Pullorum.

Rabbits are easily infected with *Bacterium pullorum*, or at least show a marked reaction when injected with pure cultures of this organism; but by a careful procedure of immunization they yield very active agglutinins and also bacteriolytic sera. From 100 tests made in this laboratory it has been found that these agglutinins elaborated in this way are much more stable than those from individuals harboring the organism. Rabbits retained in this laboratory at the present time furnish sera which were active in dilutions up to 1–5,000. Agglutinins in such sera have aided greatly in the diagnosis or differentiation of cultures of *Bacterium pullorum*.

Summary.

From the work carried out at this laboratory during the summer of 1913, the following conclusions appear to be justifiable: —

1. Although the egg test for the determination of *Bacterium pullorum* may yield positive results showing ovarian infection, the elimination is

TABLE 10.

TABLE SHOWING SPECIFICITY OF BACTERIUM PULLORUM AGGLUTININ

HEN No. HRS.	1:100	1:200	1:300	1:400	1:500	1:800	1:1000	1:1200	1:1500	1:1800	1:2000	1:2500	1:3000	1:4000	1:5000
B. COLI COMMUNIS TEST FLUID + B. PULLORUM AGGLUTININ															
A24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. COLI COMMUNIOR TEST FLUID + B. PULLORUM AGGLUTININ															
A24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. ICTEROIDES TEST FLUID + B. PULLORUM AGGLUTININ															
A24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. ENTERITIDIS TEST FLUID + B PULLORUM AGGLUTININ															
A24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. PARATYPHI A TEST FLUID + B. PULLORUM AGGLUTININ															
A24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. PARATYPHI B. TEST FLUID + B. PULLORUM AGGLUTININ															
A24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. TYPHI ABDOMINALIS TEST FLUID + B PULLORUM AGGLUTININ															
A24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. FOWL CHOLERA TEST FLUID + B. PULLORUM AGGLUTININ															
A24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. CLOACAE TEST FLUID + B. PULLORUM AGGLUTININ															
A24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. LACTIS AEROGENES TEST FLUID + B. PULLORUM AGGLUTININ															
A24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. PULLORUM TEST FLUID + B. PULLORUM AGGLUTININ															
A24	+	+	+	+	+	+	+	+	+	+	−	−	−	−	−
48	+	+	+	+	+	+	+	+	+	+	+	−	−	−	−
72	+	+	+	+	+	+	+	+	+	+	+	+	−	−	−

HEN No. HRS.	1:100	1:200	1:300	1:400	1:500	1:800	1:1000	1:1200	1:1500	1:1800	1:2000	1:2500	1:3000	1:4000	1:5000
B. COLI COMMUNIS TEST FLUID + B. PULLORUM AGGLUTININ															
BB24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. COLI COMMUNIOR TEST FLUID + B. PULLORUM AGGLUTININ															
B24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. ICTEROIDES TEST FLUID + B. PULLORUM AGGLUTININ															
B24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. ENTERITIDIS TEST FLUID + B PULLORUM AGGLUTININ															
B24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. PARATYPHI A TEST FLUID + B. PULLORUM AGGLUTININ															
B24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. PARATYPHI B. TEST FLUID + B. PULLORUM AGGLUTININ															
B24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. TYPHI. ABDOMINALIS TEST FLUID + B. PULLORUM AGGLUTININ															
B24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. FOWL CHOLERA TEST FLUID + B. PULLORUM AGGLUTININ															
B24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. CLOACAE TEST FLUID + B. PULLORUM AGGLUTININ															
B24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. LACTIS AEROGENES TEST FLUID + B. PULLORUM AGGLUTININ															
B24	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
72	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B. PULLORUM TEST FLUID + B. PULLORUM AGGLUTININ.															
B24	+	+	+	+	+	+	+	+	+	+	+	+	+	−	−
48	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−
72	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−

irregular and very often covers a long period of time before the organism is detected; therefore it is impractical for rapid diagnosis.

2. Preliminary incubation of the eggs in a bacteriological incubator at 38° to 39° C. prior to testing aids in the determination of the organism.

3. The macroscopic agglutination test as carried out in this laboratory, has proven a good laboratory method for the detection of adult hens harboring, or which have harbored, *Bacterium pullorum.*

4. Our work substantiates that of Jones, in that it is possible to cause a local infection of the ovarian tissue by intravenous injections of pure cultures of *Bacterium pullorum.*

5. The agglutinin is very stable, withstanding temperatures of 60° C. and over for one-half hour. If properly preserved, it will yield results after two weeks. Agglutinins have been found from infected hens which reacted positively in dilutions from 1–100 to 1–5,000.

6. Polyvalent test fluids yield more uniform results than monovalent fluids, although in birds of marked infection monovalent test fluids gave very good results. Test fluids if properly preserved on ice will keep in a very active state for more than two months.

7. Rabbits react to injections with pure cultures of *Bacterium pullorum,* but by careful immunization yield very active agglutinins and also bacteriolytic sera. Agglutinins produced by immunizing rabbits are much more stable than those from hens harboring the organism.

8. A striking pathological condition found in the ovaries of all birds was the exhibition of lobulated and retention cysts which varied greatly in size. From these, it was usually easy to isolate *B. pullorum.*

Acknowledgment. — Thanks are due my sister, Ethel G. Gage, for careful work in connection with calculation and rearrangement of the scientific data from our card-indexing system.

A STUDY OF VARIATION IN APPLES.

J. K. SHAW.

Beginning with the crop of 1908 the apples borne by certain Ben Davis and Baldwin apple trees growing in the college orchard have been measured, both their transverse and longitudinal diameters being taken, and this has been continued up to and including the crop of 1913. This period includes six successive seasons in each of which the Ben Davis trees have borne at least a moderate crop, but the Baldwins have shown some irregularities in bearing. This method has given opportunity for the study of the number of apples borne, the size of the apples and the index of form. Inasmuch as the fruit of each tree has been divided into four lots by bisecting the tree with one plane perpendicular and extending east and west, and with another, horizontal, and about midway of the head of the tree, we have further the opportunity of comparing these factors for what we have called the upper south, lower south, upper north and lower north portions of the trees. Two partial reports of the observations on these trees have been made. For a statement of the method used the reader may be referred to these earlier reports.[1] The present paper reports results to date, and is probably final for this phase of the problem.

The Productiveness of the Trees.

We are not aware of any published data giving the number of apples borne by individual trees for a number of consecutive years. Several have reported the measured quantities produced over a considerable period, and these records have shown marked differences in yield of individual trees. Macoun gives the total yield for several varieties. These figures are taken from his report.[2]

Variety.	Age of Trees (Years).	Years of Bearing.	Number of Trees.	Yields (Gallons).		
				Lowest.	Highest.	Average.
Wealthy,	15	12	14	57.0	203.0	113.5
McMahon,	23	13	8	226.0	889.0	604.4
McIntosh,	21	13	2	367.5	761.0	564.0
Patten,	19	13	5	291.5	597.5	406.1

[1] Repts. Mass. Expt. Station: 22, Pt. I. (1910), p. 194; 23, Pt. I. (1911), p. 177.

[2] Rept. Central Expt. Farm., 1910-11, p. 118.

The trees on which our observations have been made are eighteen years old, and all are in a healthy, thrifty condition. All have been given the usual orchard care as to pruning and spraying; all were cared for under the cultivation and cover-crop system until August, 1911, when the Baldwin plot was seeded to grass and clover. The trees are similar in size and vigor, though there is some correlation between size and productiveness in the Ben Davis. Tree No. 8 which has produced the most apples is somewhat larger than any of the other trees. The yields of the trees for the period under observation are as follows: —

	1908.	1909.	1910.	1911.	1912.	1913.	Totals.
Tree No. 2, Ben Davis, .	864	251	425	2,453	724	830	5,547
Tree No. 3, Ben Davis, .	567	343	449	1,576	641	966	4,542
Tree No. 5, Ben Davis, .	469	155	360	1,469	354	1,264	4,071
Tree No. 7, Ben Davis, .	423	431	587	1,278	837	1,010	4,566
Tree No. 8, Ben Davis, .	–	686	1,093	2,249	629	1,611	6,268

	1908.	1909.	1910.	1911.	1912.	1913.	Totals.
Tree No. 2, Baldwin, . .	–	321	287	None.	319	None.	927
Tree No. 4, Baldwin, . .	–	621	189	1,541	None.	495	2,846
Tree No. 5, Baldwin, . .	–	319	546	253	830	None.	1,948

The differences in yield between the several trees are not as great as those reported by Macoun, especially in the Ben Davis, which is one of the most regular and abundant bearers. There is little indication of the biennial bearing habit in the Ben Davis, while the Baldwins show it clearly in later years, though they all bore a crop in both 1909 and 1910. No satisfactory reason for these annual fluctuations in crop can be assigned, but it presumably lies largely in weather conditions at the blossoming season, various conditions influencing the number of fruit buds formed during the previous season, and possibly in some degree to insects and disease. The Ben Davis has blossomed freely each year, while the Baldwins have in off years failed to blossom.

Considering for a moment the yields from the different parts of the trees, divided as has been already explained, we find some slight variations of interest. The numbers of apples have been as follows: —

	Upper South.	Lower South.	Upper North.	Lower North.
1908,	518	714	414	676
1909,	552	379	305	287
1910,	707	893	576	869
1911,	2,082	2,111	2,310	2,522
1912,	791	501	677	380
1913,	1,550	1,432	1,393	1,306
Totals,	6,200	6,030	5,675	6,040

These figures are for the Ben Davis trees only, as the Baldwins have been so irregular in bearing as to seriously interfere with any significance that the figures might otherwise have. The upper south quarters of the trees have borne the greatest number of apples, and the annual fluctuations have been least. However, the difference is not great enough to have much significance. So far as it goes it is in accordance with the reasonable supposition that that part of the tree most exposed to the warmth and light of the sun sets the largest number of fruits. As will be shown later the upper south part of the trees have yielded larger apples as well as a few more, so that the yield in barrels should be sensibly greater. If this is true of the parts of the tree, may it not indicate that a southern slope will yield more than a northern one? Probably such an assumption would be hardly justified, especially as the increased size may not hold generally. Also there have doubtless been small variations in the division of the trees from year to year, but these would tend to offset each other when the whole period is considered. Warren,[1] found in Wayne County, N. Y., the highest yields on easterly slopes, while Martin, found in Ontario County that the largest yields were from orchards on level sites followed by those on north, east and west slopes in the order given.[2]

Size.

The measurements of the greatest cross diameter seem to reveal significant differences in the size of the apples in both individual trees and different parts of the tree. Of the several Ben Davis trees No. 7 has borne the largest apples, 72.92 millimeters, and No. 3 the smallest, 69.99 millimeters; and there has been a fair degree of consistency in the sizes from year to year, No. 7 not having fallen below third place in any one year, and No. 3 having risen above fourth place only once. The other three trees have shown greater fluctuation from year to year, all having occupied both first and last places in the course of the six years of observation, and the differences in averages are not large. The few figures available for the Baldwins are greater and are consistent from year to year. Tree

[1] Cornell Bull. 226, p. 326.

[2] Cornell Bull. 307, p. 107.

No. 2 has borne the largest apples and tree No. 4 the smallest, with tree No. 5 intermediate each year. The apples on tree No. 4 were much smaller in 1913 than ever before, due possibly to the previous seeding down to grass and clover.

It seems fair to conclude that individual trees may show a fairly constant tendency from year to year to produce apples larger or smaller than the general average of the orchard.

The extreme difference in average size between the individual trees amounts to a trifle less than 3 millimeters, while between the different parts of the trees it is 2.38 millimeters; but from year to year the differences are more consistent. The apples from the upper south part of the trees have been the largest every year. Those from the upper north part have been second every year except 1911, while the lower north apples have been smallest in four years out of six. This would seem to warrant the conclusion that for the variety the better the exposure of the trees to the sun the larger the growth that may be secured.

The figures for the Baldwins are too fragmentary to be of much value, but so far as they go, while not quite as consistent as those of the Ben Davis, they show the same general tendency. In 1909 the different parts were in the same order as the average of the Ben Davis, while in 1912 the upper north led, followed by the upper south, lower north and lower south.

Considering the average size of the total apples from the Ben Davis trees in the several years we note that they were largest in 1910 and smallest in 1911, the difference between the extremes being 4.04 millimeters. The small size in 1911 is undoubtedly due to the heavy crop borne, but it is significant that this is the only year in which the trees have borne enough to affect the size. There is no relation between size of apples and the number borne until the crop reaches what may be fairly termed a full crop. Probably there is more danger of breaking down the tree than of any serious deficiency in size, provided the trees are well cared for. In 1909 the apples average 90 millimeters in diameter, nearly as small as in 1911. The probable explanation of this is the low temperature prevailing, the March–October mean being the lowest of any of the six years under consideration. There are some further indications of a relationship between the warmth of the season and the size of the apples, but all the fluctuations in size cannot be thus accounted for. We have been unable to trace any relationship whatever between precipitation and size. One possible influence of fertilization is in the case of the crop of 1910, the large size of which may be due to a previous application of lime.

While there is evidence that there has been some relation between mean summer temperature and size it does not appear that the slight variations that have occurred have exercised a controlling influence on the size of the apples. In earlier work along this line a greater effect of temperature was observed, but mostly from stations further north, where seasonal fluctuations of temperature are greater.

A study of the variability in size of the apples from the different trees shows small differences that apparently have some meaning. Those from tree No. 7 are quite consistently the most variable of any, and these have been the largest; there seems to be a possible relationship between size and variability, — the larger the apples the more variable.

As between the apples from different parts of the tree, this relationship does not hold. The apples from the upper south parts of the trees are largest and least variable, and probably the slight differences in variability that occur are simply chance fluctuations.

TABLE 1.—*Size of Apples.*

Ben Davis.

INDIVIDUAL TREES.

Tree No. 2.

[Millimeters.]

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	71.02±.14	6.16±.10	8.67±.14
1909,	70.89±.22	5.40±.16	7.62±.18
1910,	73.15±.19	5.69±.13	7.78±.15
1911,	69.15±.07	5.15±.05	7.45±.07
1912,	71.01±.18	6.68±.12	9.41±.17
1913,	75.63±.16	5.43±.09	7.18±.12
Average,	71.81	5.75	8.02
Tree No. 3.			
1908,	68.80±.15	5.31±.11	7.72±.16
1909,	68.48±.19	5.24±.13	7.65±.22
1910,	72.27±.19	6.01±.13	8.32±.22
1911,	69.14±.07	4.11±.05	5.94±.07
1912,	71.71±.15	5.60±.11	7.81±.15
1913,	69.54±.09	4.90±.08	7.04±.06
Average,	69.99	5.20	7.41
Tree No. 5.			
1908,	68.35±.13	5.55±.08	8.12±.13
1909,	68.32±.27	4.96±.18	7.26±.33
1910,	75.53±.21	5.88±.15	8.00±.22
1911,	70.16±.09	5.29±.07	7.55±.09
1912,	74.01±.25	7.08±.18	9.57±.24
1913,	71.69±.13	4.85±.07	6.76±.09
Average,	71.34	5.70	8.02

TABLE 1. — *Size of Apples* — Continued.

Tree No. 7.

[Millimeters.]

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	72.80±.18	6.45±.13	8.86±.17
1909,	70.37±.17	5.12±.12	7.28±.19
1910,	75.12±.19	6.85±.14	9.12±.21
1911,	72.69±.11	6.11±.08	8.41±.11
1912,	72.57±.15	6.33±.10	8.72±.14
1913,	73.97±.12	5.69±.09	7.70±.12
Average,	72.92	6.09	8.35

Tree No. 8.

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1909,	70.45±.13	4.93±.09	7.00±.13
1910,	72.57±.09	6.16±.06	8.52±.10
1911,	67.12±.08	5.71±.06	8.50±.09
1912,	73.39±.16	5.79±.11	7.90±.15
1913,	71.93±.09	5.48±.09	7.62±.13
Average,	71.69	5.60	7.82

PARTS OF THE TREES.

Upper South.

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	70.93±.18	6.40±.13	9.02±.19
1909,	70.96±.14	4.77±.10	6.72±.14
1910,	74.53±.12	4.67±.08	6.27±.11
1911,	70.79±.08	5.66±.06	8.00±.08
1912,	74.34±.13	5.41±.09	7.27±.12
1913,	73.08±.10	5.40±.07	7.39±.09
Average,	72.44	5.38	7.45

Lower South.

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	69.24±.14	5.68±.10	8.20±.14
1909,	69.77±.18	5.06±.12	7.24±.18
1910,	72.87±.14	6.33±.10	8.68±.14
1911,	69.86±.08	5.46±.06	7.81±.11
1912,	70.76±.22	7.28±.16	10.29±.22
1913,	71.45±.09	5.27±.07	7.38±.09
Average,	70.66	5.86	8.27

TABLE 1. — *Size of Apples* — Continued.

Upper North.

[Millimeters.]

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	71.27±.20	6.14±.15	8.47±.19
1909,	70.86±.20	5.27±.13	7.44±.19
1910,	73.94±.21	6.51±.14	8.80±.19
1911,	69.09±.08	5.65±.06	8.17±.08
1912,	72.37±.15	6.02±.11	8.31±.15
1913,	72.84±.10	5.41±.05	7.43±.09
Average,	71.73	5.83	8.10

Lower North.

1908,	69.79±.12	4.96±.08	7.11±.12
1909,	69.40±	5.04±	7.26±
1910,	72.32±.14	6.06±.10	8.38±.14
1911,	67.57±.07	5.55±.05	8.21±.08
1912,	70.84±.21	5.93±.15	8.37±.21
1913,	70.43±.09	5.07±.09	7.19±.08
Average,	70.06	5.43	7.75

TOTAL APPLES.

1908,	70.23±.08	5.95±.06	8.47±.08
1909,	70.00±.08	5.11±.06	7.30±.08
1910,	73.27±.08	6.28±.06	8.57±.08
1911,	69.23±.04	5.70±.03	8.24±.04
1912,	72.42±.08	6.31±.05	8.71±.07
1913,	73.19±.05	5.44±.03	7.44±.05

Baldwins.

INDIVIDUAL TREES.

Tree No. 2.

1909,	78.62±.21	5.59±.15	7.11±.23
1910,	80.22±.23	5.41±.16	6.74±.27
1912,	79.20±.23	6.05±.16	7.64±.20

TABLE 1. — *Size of Apples* — Concluded.

Tree No. 4.

[Millimeters.]

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1909,	74.39±.14	5.01±.10	6.73±.15
1910,	76.90±.27	5.57±.19	7.24±.30
1911,	71.78±.08	4.58±.06	6.38±.06
1913,	66.91±.20	6.52±.15	9.74±.22
Tree No. 5.			
1909,	77.66±.21	5.66±.15	7.29±.22
1910,	77.71±.15	5.20±.11	6.69±.15
1911,	78.05±.26	6.07±.18	7.78±.23
1912,	74.16±.12	5.19±.08	7.00±.11
PARTS OF THE TREES.			
Upper South.			
1909,	76.91±.18	5.61±.12	7.29±.16
1912,	77.50±.22	5.47±.16	7.06±.20
Lower South.			
1909,	76.31±.23	5.83±.16	7.64±.21
1912,	73.02±.23	6.11±.17	8.36±.23
Upper North.			
1909,	76.34±.20	5.47±.14	7.19±.19
1912,	77.96±.21	5.41±.15	6.94±.19
Lower North.			
1909,	74.58±.26	5.14±.18	6.89±.25
1912,	74.86±.22	5.58±.16	7.45±.21
TOTAL APPLES.			
1909,	76.29±.11	5.68±.08	7.45±.10
1910,	77.99±.11	5.55±.08	7.12±.10

Form.

The main purpose of this work has been the study of the variation in form of the apples and the causes thereof. The continuation of our observation has resulted in the accumulation of data that confirm earlier conclusions[1] and afford basis for some further deductions concerning the problem.

Ben Davis tree No. 7 which has borne the largest apples has also borne the most flattened of any, while the most elongated have been from tree No. 8 closely followed by tree No. 2. The mean indexes of form from year to year have also been fairly consistent, No. 7 ranking first four times, second once and fourth once during the six years. The other trees have been more variable, but trees Nos. 2 and 8 have shown a tendency toward elongation. As with size the differences in form are more constant in the different parts of the trees than with the different trees. The upper south apples have been the most flattened every year, but those of trees Nos. 1 and 3 from the lower north portions have been the most elongated four years out of six. The other two portions of the trees have been more variable, but the lower souths have been slightly the more flattened. As regards the standard deviation and the coefficient of variability, they do not seem to have any significance whatever; such small differences as occur are probably wholly chance fluctuations.

Turning now to the discussion of the difference in form from year to year and its relation to air temperature, which has been the main object of inquiry, we find that the paralellism between the variation and the temperature for a period following blossoming previously observed has been maintained in succeeding years. This relationship is shown in Fig. 1, which shows the fluctuations in mean daily temperature for twenty-five days following full bloom. This shows that a low temperature following blossoming is always followed by a low coefficient of form, *i.e.*, relatively elongated apple. The past season of 1913 has been the coolest of any for nearly the whole period of twenty-five days, and the apples have been the most elongated, while in 1908, 1911 and 1912, in which this period was relatively warm, the coefficient of form is much larger, *i.e.*, the apples are more flattened. In the other years both the temperatures and coefficients of form have been intermediate.

The curves of temperature, not only for the period shown in the diagram but for the entire growing season as well, have been carefully scrutinized to ascertain the critical period which determines the form of the apple. Consideration has also been given to other factors of climate, such as rainfall, humidity and sunshine, — whether they may have an effect. As a result of this inquiry there appears no evidence that factors other than that of temperature for a part or all of the twenty-five-day period have any influence. Within this period the temperature from the sixth to

[1] Mass. Expt. Station Rept.: 23, Pt. I. (1911), p. 199.

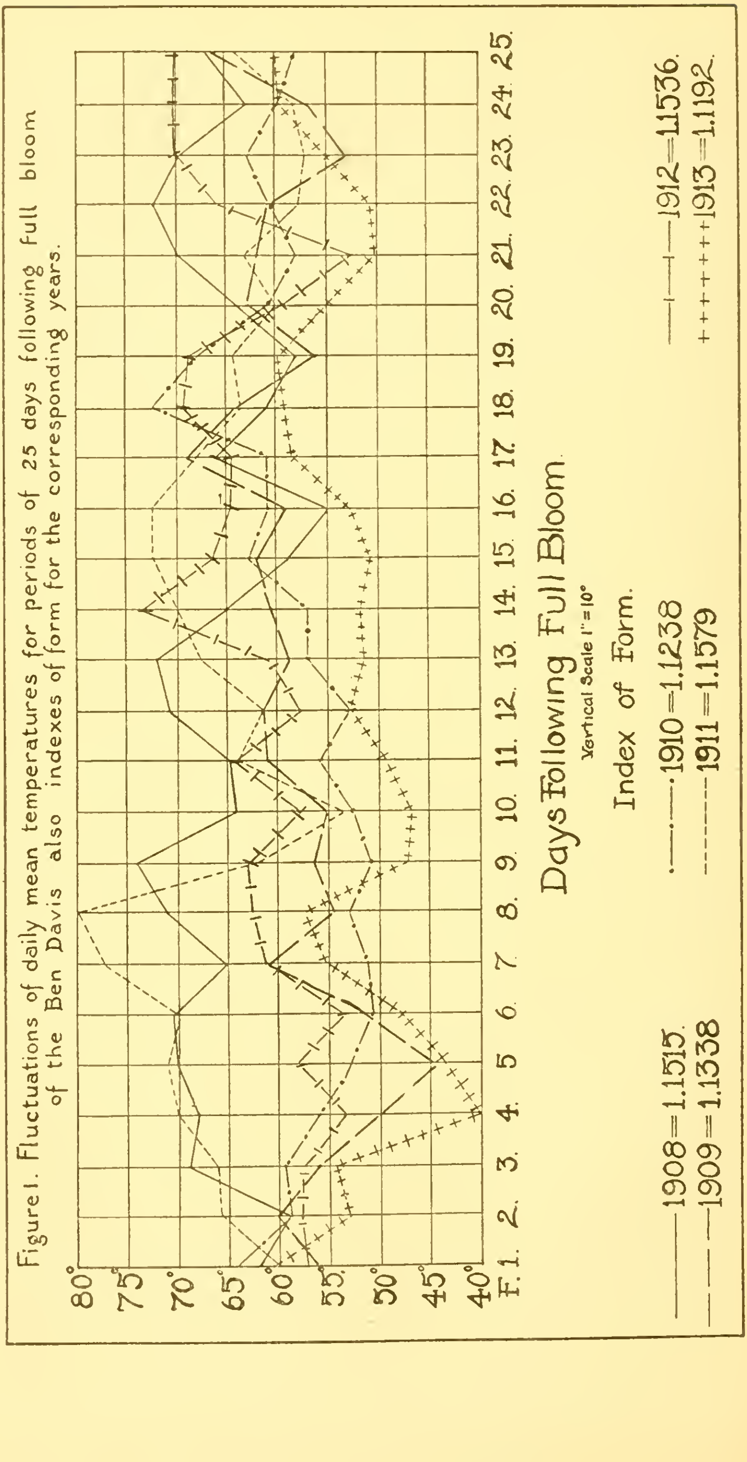

Figure 1. Fluctuations of daily mean temperatures for periods of 25 days following full bloom of the Ben Davis also indexes of form for the corresponding years.

sixteenth day seems to fit the observed fluctuations in form better than that for any other period. The relationship of the temperature for this period and the coefficient of form are as follows, the arrangement being in the order of the increase of temperature: —

Year.	Date of Full Bloom.	Temperature, Sixth to Sixteenth Day.	Coefficient of Form.
1913,	May 7,	51.24	1.1192
1910,	May 7,	54.44	1.1238
1909,	May 19,	58.19	1.1338
1912,	May 11,	62.10	1 1536
1908,	May 19,	67.63	1.1515
1911,	May 15,	67.76	1.1579

An inspection of these figures shows the general relationship, but there are some irregularities, especially in 1912 and 1908. In the latter year this period was slightly over 5° warmer than in 1912, yet the apples were more elongated. Tree No. 8 was not measured in 1908, but its apples have only once been more flattened than the average and then only slightly so. The difference between extremes of temperature for this period is 16.52° (67.76°–51.24°), and in the coefficient of form, .0387 (1.1579–1.1192). This gives an average difference of .0022 for each degree of temperature. If we calculate the relationship of the increase of the coefficient of form with that of temperature from year to year we get the following: —

Year.	Increase of Temperature.	Increase of Coefficient of Form.	
		Theoretical.	Actual.
1913,	0	0	0
1910,	3.20	.0070	.0046
1909,	6.95	.0151	.0146
1912,	10.86	.0238	.0344
1908,	15.39	.0339	.0328
1911,	16.52	.0363	.0387

Looked at from this viewpoint the only very serious difference between the actual and theoretical increases of the coefficient of form with the rise of temperature is in 1912, when it is 1.1536, whereas it should be, in order to be in harmony with other years, 1.1430. We have endeavored to account for this irregularity, but without success. Presumably some unknown factor operated to disturb the fairly close relationship observed in other years. Probably it will be necessary to attack the problem from another angle in order to understand what this may be.

TABLE 2.—*Form of Apples.*

Ben Davis.

INDIVIDUAL TREES.

Tree No. 2.

[Millimeters.]

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	1.1422±.0014	.0576±.0009	3.04±.08
1909,	1.1248±.0024	.0553±.0017	4.91±.15
1910,	1.1159±.0016	.0516±.0012	4.62±.12
1911,	1.1526±.0006	.0458±.0004	3.97±.04
1912,	1.1510±.0016	.0510±.0009	4.43±.09
1913,	1.1282±.0014	.0584±.0010	5.18±.09
Average,	1.1358	.0533	

Tree No. 3.

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	1.1399±.0016	.0543±.0011	4.73±.09
1909,	1.1297±.0020	.0553±.0014	4.89±.19
1910,	1.1322±.0015	.0488±.0011	4.31±.11
1911,	1.1662±.0008	.0456±.0005	3.91±.05
1912,	1.1508±.0016	.0586±.0011	5.09±.09
1913,	1.1282±.0012	.0547±.0008	4.85±.07
Average,	1.1412	.0529	

Tree No. 5.

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	1.1666±.0019	.0626±.0013	3.76±.08
1909,	1.1295±.0028	.0519±.0019	4.59±.19
1910,	1.1151±.0018	.0512±.0013	4.59±.12
1911,	1.1559±.0008	.0453±.0006	3.92±.05
1912,	1.1571±.0018	.0549±.0014	4.75±.12
1913,	1.1201±.0009	.0492±.0007	4.39±.07
Average,	1.1418	.0526	

Tree No. 7.

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	1.1716±.0019	.0578±.0013	3.37±.07
1909,	1.1486±.0017	.0511±.0012	4.45±.11
1910,	1.1333±.0014	.0516±.0010	4.55±.09
1911,	1.1716±.0010	.0528±.0007	4.51±.06
1912,	1.1563±.0012	.0483±.0008	4.17±.07
1913,	1.1170±.0012	.0549±.0008	4.91±.07
Average,	1.1497	.0527	

TABLE 2. — *Form of Apples* — Continued.

Tree No. 8.

[Millimeters.]

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1909,	1.1310±.0013	.0494±.0010	4.37±.09
1910,	1.1211±.0007	.0481±.0005	4.29±.05
1911,	1.1558±.0006	.0455±.0005	3.93±.04
1912,	1.1540±.0013	.0491±.0009	4.14±.08
1913,	1.1099±.0006	.0473±.0008	3.94±.07
Average,	1.1342		

PARTS OF TREES.

Upper South.

1908,	1.1643±.0017	.0593±.0012	3.61±.07
1909,	1.1390±.0015	.0520±.0011	4.57±.10
1910,	1.1299±.0013	.0500±.0009	4.43±.09
1911,	1.1610±.0004	.0486±.0005	4.19±.04
1912,	1.1557±.0012	.0505±.0009	4.37±.07
1913,	1.1283±.0009	.0513±.0006	4.55±.06
Average,	1.1464	.0523	

Lower South.

1908,	1.1512±.0015	.0619±.0011	4.19±.07
1909,	1.1302±.0018	.0516±.0012	4.57±.12
1910,	1.1249±.0011	.0489±.0009	4.35±.08
1911,	1.1614±.0009	.0468±.0005	4.03±.04
1912,	1.1609±.0014	.0461±.0010	3.97±.08
1913,	1.1156±.0007	.0416±.0005	3.73±.05
Average,	1.1407	.0496	

Upper North.

1908,	1.1553±.0020	.0607±.0014	3.91±.08
1909,	1.1333±.0020	.0509±.0014	4.40±.14
1910,	1.1216±.0016	.0544±.0010	4.85±.10
1911,	1.1598±.0004	.0470±.0005	4.05±.04
1912,	1.1430±.0013	.0487±.0009	4.26±.08
1913,	1.1241±.0010	.0527±.0007	4.34±.06
Average,	1.1395	.0527	

TABLE 2. — *Form of Apples* — Continued.

Lower North.

[Millimeters.]

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	1.1406±.0016	.0644±.0011	4.58±.07
1909,	1.1338±.0021	.0529±.0015	4.67±.14
1910,	1.1171±.0012	.0505±.0008	4.52±.08
1911,	1.1511±.0006	.0454±.0004	3.95±.04
1912,	1.1537±.0018	.0505±.0012	4.37±.11
1913,	1.1065±.0009	.0529±.0007	4.78±.06
Average,	1.1338	.0528	

TOTAL APPLES.

1907,	1.1656±.0023	.0581±.0017	4.98±.14
1908,	1.1515±.0008	.0589±.0006	5.29±.05
1909,	1.1338±.0009	.0527±.0006	4.65±.06
1910,	1.1238±.0007	.0504±.0004	4.48±.04
1911,	1.1579±.0003	.0472±.0002	4.07±.02
1912,	1.1536±.0006	.0499±.0004	4.33±.04
1913,	1.1192±.0005	.0518±.0003	4.63±.08

Baldwins.

INDIVIDUAL TREES.

Tree No. 2.

1909,	1.1615±.0022	.0579±.0015	4.98±.13
1910,	1.1745±.0021	.0536±.0015	4.56±.15
1912,	1.2006±.0023	.0605±.0016	5.04±.14

Tree No. 4.

1909,	1.1848±.0014	.0523±.0010	5.41±.10
1910,	1.1834±.0027	.0553±.0019	4.67±.17
1911,	1.2342±.0008	.0469±.0006	3.80±.05
1913,	1.1962±.0024	.0774±.0017	6.47±.15

TABLE 2. — *Form of Apples* — Concluded.

Tree No. 5.

[Millimeters.[

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1909,	1.1790±.0024	.0644±.0017	5.46±.16
1910,	1.1878±.0018	.0622±.0013	5.23±.12
1911,	1.2307±.0027	.0637±.0019	5.18±.16
1912,	1.2248±.0011	.0485±.0008	3.96±.07
Total Apples.			
1909,	1.1774±.11	.0583±.08	4.96±.07
1910,	1.1844±.12	.0567±.08	4.79±.07
1912,	1.2180±.10	.0502±.07	4.27±.06

Summary.

1. These Ben Davis trees have borne much more heavily than the Baldwins and have shown hardly any tendency to biennial bearing.

2. Among five Ben Davis trees the most prolific tree has exceeded the least prolific by more than 60 per cent. in number of apples in the total for six crops. The Baldwins have shown even greater differences.

3. The upper south quarters of the Ben Davis trees have borne a few more apples than any of the other three quarters. This may be significant or only a chance difference.

4. Some Ben Davis trees showed a fairly constant tendency to produce apples larger or smaller than the average; others fluctuated from season to season.

5. Ben Davis apples from the upper south quarters of the trees run constantly larger than those from the other parts; those from the opposite quarters were generally smallest.

6. Only once in the case of a very heavy crop has the number of apples been large enough to affect the size.

7. There are some slight indications of a relationship between size and the average summer temperature, but the fluctuations in temperature have probably not been large enough to overcome other influences affecting size.

8. Some trees showed slight individuality in the amount of variability, and this may be correlated with size, — the larger the apples the more variable. This is not true as between the different parts of the trees.

9. As with size, some trees showed quite constant individuality in form of fruit, while others were variable. There seems to be no strong evidence that individuality in size and form are to be found in the same tree.

10. The apples from the upper south parts of the trees, which were largest, were also constantly the most flattened.

11. There is a pretty constant relationship between the form of the apple and the temperature for a period following bloom; the cooler this period the more elongated the apple.

12. An effort to delimit this period more closely indicates that the period from the sixth to the sixteenth days following full bloom fits the observed fluctuation in form more closely than any other.

REPORTS ON EXPERIMENTAL WORK IN CONNECTION WITH CRANBERRIES.

H. J. FRANKLIN AND F. W. MORSE.

REPORT OF CRANBERRY SUBSTATION FOR 1913.[1]

The year's experiments and observations may be discussed under the ten following heads: weather observations, frost protection, fungous diseases, varieties, blossom pollination, fertilizers, insects, weeds, resanding and miscellaneous.

1. WEATHER OBSERVATIONS.

Blanks have been prepared for recording on a single sheet all the more important phenomena observed in connection with every frosty night during the cranberry growing season. On these blanks space has been left for recording the minimum temperatures at 15 stations (bogs) besides that at the station bog. It is also planned to note in this record the amount of injury (estimated) on the Cape and in New Jersey caused by each severe frost. It is hoped that the mass of data condensed in such records will make it possible to better understand the Cape frost weather conditions and to make more satisfactory frost predictions as a result. Only a few of the temperature observing stations planned for have, as yet, been established, but it is hoped that another season will see all the thermometers properly placed for taking a fairly representative lot of minimum temperature observations for the entire Cape. The barometric changes and their influence on frost conditions, both as indicated by the weather map and as shown by the action of the barometer itself, have been carefully studied, with some interesting results. The high barometric waves appear, as a rule, to be most dangerous when they extend both far to the North and far to the South, without any low wave on the Atlantic seaboard to the south of us. One of the great uncertainties about the barometric action, as far as the weather map is concerned, seems to be caused by the occasional more rapid deepening of a low wave in or around the lower St. Lawrence valley, than is offset by the advance of the high wave, the general result being a fall of the barometer in an important

[1] By H. J. Franklin.

section where a rise would, as a rule, be expected. This fall of the barometer in the northeast often causes the wind to keep up all night when other conditions would lead a forecaster to expect almost a dead calm. There seems to be no way of figuring on this action of the barometric waves, except by more extensive observations of conditions in the eastern Provinces of Canada than are at present carried out by the Weather Bureau. The officials of the Weather Bureau are planning to take special afternoon barometric observations in that section, in order to forecast our frost conditions more accurately.

Another puzzling factor is the occasional occurrence of cloudiness on mornings when, from the general weather conditions, no cloudiness would naturally be expected. It seems quite possible that we may not be able to fully understand the causes of such cloudiness without a study of the conditions of the upper atmosphere. This is of course a very important matter, for the presence of clouds always makes a difference of several degrees in the temperature of a cold night.

The readings of the maximum and minimum shelter and bog thermometers, and the amounts of precipitation, were telegraphed to the office of the United States Weather Bureau at Boston, every morning after May 4, during the spring and fall periods of frost danger. Triple register (for sunshine, wind direction and wind velocity), thermograph, and barograph records were taken in the usual way throughout the season, from early May until the last of October. As the hydrograph did not work satisfactorily no records were made with that instrument.

There seems to have been this year a general increase in confidence, on the part of the growers, in the forecasts sent out from the Boston office of the Weather Bureau. This increased confidence is probably fully justified, for the forecasts seem to have been much more accurate during the past season than formerly.

2. FROST PROTECTION.

Careful consideration has been given to the different possible methods of frost protection where water is not available for use in the usual way.

It was suggested in last year's report that it might be possible to use the Skinner system, or some other sprinkling arrangement, with an engine and pump only large enough to pump water for one section at a time, the idea being to draw the frost out of the vines by one or two applications of cold water in the morning, before they were thawed out by the heat of the sun. The practicability of this method was tried out on a small scale last May with a spraying outfit, and the results seemed to be far from satisfactory, for the sprayed areas afterward appeared to show distinctly more injury than did the surrounding unsprayed portions of the bog. As the whole matter now stands, therefore, it does not seem at all probable that the Skinner system can very well ever be made practical use of for frost protection. Its undesirability from the standpoints of expense and nozzle clogging were discussed in last year's report. All other sprinkling systems at present on the market are even more expensive, and will probably, on this account, never be practically available for this purpose.

As indicated in last year's report, the expense connected with the use of orchard heaters is prohibitive, to say nothing of the danger from fire, and of the injury to the vines which would unavoidably be done by the spilling of oil.

There are many other possible methods of frost protection for cranberry bogs which have not yet been tried. It may be possible to cause the frost to be drawn out slowly from the vines after a frost by screening the bog from the sun during the first two or three hours of the morning, perhaps by a curtain of smoke. This method is suggested by the well-known fact that the greater part of the injury, caused by freezing in both plant and animal tissues, is usually due more to the sudden withdrawal of the frost in the process of thawing than to the formation of the frost in them.

The possibility of protecting a bog from frost by covering it over with cloth is of course generally recognized. Though this would be an expensive protection, it has the probable advantage of being entirely effective. It is, however, probably unwise to attempt any special frost protection on dry bogs because of the peculiar conditions and difficulties otherwise associated with such bogs. The only kind of bogs, the general conditions of which probably warrant special protection, are those which are winter-flowed but cannot be reflowed to any extent.

As a rule, the managers and owners of most of the Cape bogs, which have poor frost protection, seem to have overlooked the method of protection, which, though not perfect, is, nevertheless, many times very effective, and which can be applied with a relatively small cost, namely, that of keeping the bog well sanded. It has been shown by the experiments carried out by Prof. H. J. Cox for the United States Weather Bureau and by the Wisconsin Station that there is a protection against several degrees of frost to be had by this use of sand. Many of the Cape growers have come to realize this from general experience, and striking examples of the efficiency of this protection are not infrequently seen. It seems certain that a very considerable percentage of the Cape cranberry losses from frost, incurred where water protection is not available, could be saved by a more general understanding and application of this principle of re-sanding for protection.

3. FUNGOUS DISEASES.

The arrangement by which this work has heretofore been carried on in co-operation with the Bureau of Plant Industry of the United States Department of Agriculture has been continued this year. Dr. Shear has had general supervision of the spraying experiments as heretofore and has conducted the laboratory investigations. A considerable number of spraying tests were carried on by the growers, especially in Wareham and in and about Harwich, the results of some of which have not as yet been received. The five plots, each four rods square, which were sprayed in 1911 and 1912 as indicated in previous reports, were all sprayed again this season with Bordeaux mixture used in the same way as last year (3 pounds of lime, 4 pounds of copper sulphate and 2 pounds of resin fish oil soap to 50 gallons of water), but a greater number of times, plots A and C (Lake Howe plots) being sprayed with the Bordeaux on June 5, June 17, June 28 and July 19, and with neutral copper acetate (1 pound to 50 gallons of water) on August 7. Plot B (the McFarlin plot) was sprayed with Bordeaux mixture on June 6, June 18 and July 21. Plots D and E (the Early Black plots) were sprayed with Bordeaux mixture on June 6, June 18, July 11 and July 22. The crop was gathered from these plots and their checks on dates and in amounts as follows, the quantities being given in bushels: —

TABLE 1.

PLOT.	Area (Square Rods).	Date when picked.	Variety.	Quantity of Fruit (Bushels).	Quantity per Square Rod (Bushels).	Average of Double Checks per Square Rod.	Per Cent. of Decrease on Sprayed Plots.
A, ...	16	Sept. 24	Howe.	8⅙	.5100	–	74
A (check 1), .	4	Sept. 25	Howe.	4 1/15	1.0170	1.942	–
A (check 2), .	9	Sept. 25	Howe.	25⅘	2.8660		
B, ...	14⅛	Sept. 25	McFarlin.	13¼	.9380	–	49
B (check), . .	13⅔	Sept. 25	McFarlin.	25	1.8300	–	–
C, ...	16	Sept. 24	Howe.	9	.5625	–	53
C (check 1), .	4	Sept. 24	Howe.	5	1.2500	1.198	–
C (check 2), .	8	Sept. 24	Howe.	9⅙	1.1460		
D, ...	16	Sept. 17	Early Black.	19⅔	1.2300	–	45
D (check 1), .	3	Sept. 17	Early Black.	6⅖	2.1330	2.240	–
D (check 2), .	9	Sept. 24	Early Black.	21⅑	2.3460		
E, ...	16	Sept. 3	Early Black.	21½	1.3440	–	26+
E (check 1), .	8	Sept. 3	Early Black.	15	1.8750	1.830	–
E (check 2), .	4	Sept. 3	Early Black.	6½	1.6250		
E (check 3), .	4	Sept. 3	Early Black.	8	2.0000		

It will be seen from this table that there was a general very marked falling off in the fruit produced by these sprayed plots as compared with the surrounding untreated portions of the bog. Where two checks were laid out for the same plot (as noted in the table), they were in every case located on different sides of the sprayed area. The berries were all picked with scoops. The spraying was done with a 30-gallon wheeled-barrel outfit, as heretofore, but the mechanical injury done in the process of spraying was not very great, as a long hose was used, and the outfit was in no case taken onto either the sprayed areas or their checks. The general result of this spraying is interesting in the light of the observations made in connection with the Early Black and McFarlin plots in the late fall of 1912. At that time it was noticed that these plots seemed to have foliage of a much lighter and more sickly appearance than was shown by the vines of their checks. As noted in last year's report, this contrast was very marked and led to the suspicion that, on account of the evidently unthrifty condition of the sprayed areas, they would not, in the season of 1913, produce as good a crop as their checks. The situation suggests that there was not sufficient available plant food present for the sprayed vines, while they were producing the 1912 crop, to maintain a strong vine condition and at the same time develop the extra amount of fruit which the reduction of fungous diseases, caused by the spraying, had made possible. Whether this was the real cause for the decreased fruiting of these plots, or whether the spraying had done the bog injury in some unknown way, it is, as yet, impossible to state with certainty. It should be noted in this connection that in the fall of 1913 the vines of all these plots showed an even more marked unthrifty and sickly appearance in comparison with their checks than they did in the fall of 1912, though they had not, as shown in the table, produced nearly as large crops as the checks. The Howe plots (A and C), which did not show in 1912 any marked effect on the vines, in the fall of 1913 were so red all over (except the fertilized middle portion of plot A) as to give the impression, to one viewing the bog from a distance, that the fireworm had been working severely on them. This would seem to indicate that the spraying had in some way caused a cumulative injury.

On June 28, the middle half of plot A (one of the Howe plots) was fertilized, a quarter of the plot on each side being left without fertilizer, the fertilizer being used on the middle portion at the following rate: nitrate of soda, 200 pounds per acre; acid phosphate, 400 pounds per acre; high-grade sulphate of potash, 200 pounds per acre. This fertilized middle half (8 square rods) of the plot produced 5 1/12 bushels of berries, while the unfertilized side strips (the area of each being 4 square rods) produced, respectively, 1 1/12 bushels and 2 bushels. It will be seen from these figures that there was a very marked increase of fruit on the middle portion, due to the application of the fertilizer. This is particularly interesting because, at the time when the fertilizer was applied, the vines were going out of bloom, and there was no rain to speak of, to dissolve the fertilizer and wash it into the soil, for several days after the application. It is the first time in our experience that fertilizers have been known to cause a marked increase in the amount of fruit on a cranberry bog in the first season applied. This is suggestive in several ways. It looks as though vines which have borne a larger crop, due to freedom from fungous disease brought about by spraying, need an extra supply of plant food the following year in order to maintain their vigor and hold their own in fruiting with unsprayed vines. The results of this fertilizing and spraying may perhaps also be taken to indicate that fertilizers will do their best work in driving fruit production only when the vines are comparatively free from fungous disease. They also suggest the possibility that there is a best time for applying fertilizers, in order to get the best fruiting, perhaps at about the blossoming period. A rather marked increase in fruit production, following a first application of fertilizers rich in nitrates, during the blossoming period, on Howe vines, was noted on some other bogs toward the close of the season. There seems to be much yet to be learned along these lines by further experimenting.

An unexpected result of the spraying, noticed on all five of our old fungous plots during the season, was the killing of the wood moss. This moss appears to have been completely killed out on every one of these plots, while, on the general bog surrounding some of them, it is present in considerable abundance and very much alive up to the very edge of the plot.

When the fruit was gathered from these five plots, no marked difference in color between the berries from the sprayed plots and their checks was observed. The size of the berries from the Early Black and McFarlin plots was practically the same as that of the berries from the checks, but the berries from plots A and C (Howe plots) were distinctly smaller than those from their checks, as shown by the following averages of counts of berries in cupful samples (New England Cranberry Sales Company's inspector's cup) from the different plots and their checks, the samples being in each case taken as evenly as possible from the various boxes: —

TABLE 2.

Plot.	Number of Samples counted.	Average Number of Berries per Sample.	Variety.
A (fertilized middle portion),	8	96	Howe.
A (the unfertilized side portions),	4	97	Howe.
A (check),	8	90	Howe.
B,	8	60	McFarlin.
B (check),	8	61	McFarlin.
C,	8	102	Howe.
C (check),	8	96	Howe.
D,	6	113	Early Black.
D (check 1),	4	110	Early Black.
D (check 2),	6	108	Early Black.
E,	6	109	Early Black.
E (check),	6	109	Early Black.

The keeping qualities of the berries from these five old fungous plots and their checks were tested, with the results shown in the following table: —

TABLE 3.

PLOT.	Date picked.	Test begun.	Test ended.	Quantity tested (Boxes).	Quantity of Sound Fruit after screening (Boxes).	Percentage of Loss.	Variety.
A (fertilized middle portion).	Sept. 24	Oct. 28	Dec. 19	4	3 3/8	15 3/5	Howe.
A (unfertilized side portions).	Sept. 24	Oct. 28	Dec. 19	2	1 2/3	17 2/3	Howe.
A (check), . .	Sept. 24	Oct. 28	Dec. 20	4	3 1/14	23 1/6	Howe.
B, ...	Sept. 25	Oct. 28	Dec. 23	4	3 1/13	23	McFarlin.
B (check), . .	Sept. 25	Oct. 28	Dec. 23	4	3	23	McFarlin.
C, ...	Sept. 24	Oct. 28	Dec. 19	4	3 5/8	10 3/10	Howe.
C (check), . .	Sept. 24	Oct. 28	Dec. 19	4	3 1/7	21 1/3	Howe.
D, ...	Sept. 17	Oct. 28	Dec. 22	3	2 1/11	30 3/5	Early Black.
D (check 1), . .	Sept. 17	Oct. 28	Dec. 20	2	1 1/4	38 1/4	Early Black.
D (check 2), . .	Sept. 24	Oct. 28	Dec. 23	3	1 2/3	44 1/8	Early Black.
E, ...	Sept. 3	Oct. 28	Dec. 17	3	2 1/2	17 2/3	Early Black.
E (check), . .	Sept. 3	Oct. 28	Dec. 17	3	2 1/8	29 3/5	Early Black.

The boxes used in measuring for these tests, as well as for all other keeping tests conducted during the season, measured 19¼ inches by 14½ inches by 8½ inches, and no considerable error was allowed to creep into the measurement of the fruit on account of variation in the dimensions of the boxes. The fractions given in the above table are only approximate, it being considered that absolute accuracy is not of sufficient importance to call for the including of large numbered fractions. In all the season's storage tests the berries were stored without screening or hoppering. When they were picked, the vines were cleaned out from the boxes by hand as carefully as possible, so that there might be uniformity among the boxes in the quantity of vines they contained. When measured for storage (on October 28 and 29), the boxes were carefully shaken and filled level full, and after screening the berries were again thoroughly shaken before they were measured.

Judging from the figures, concerning the berries from plots D and E given in Table 3, it might be thought that these tests showed a superior keeping quality for early picked berries. While it is not, of course, impossible that this factor may have entered into the results of the tests, it should be borne in mind that the two plots in question are located on the bog at a considerable distance from each other, and there is always more or less variation in the berries of the same variety harvested from the different portions of the bog. Supporting this fact is the fact that last year the berries from plot D kept better than did those from plot E, the reverse of the results obtained by our keeping tests this year.

The results of the tests of the keeping qualities of the berries of the McFarlin plot and its check are remarkable in that they appear to indicate absolutely no effect resulting from the spraying, a result never before even nearly approximated in any test of berries, which had been sprayed with Bordeaux mixture, carried out at the station bog. It should be noted in this connection that the McFarlin berries, both sprayed and unsprayed, on the station bog, and apparently also on other bogs in its vicinity, kept unusually well this year, apparently as a natural result of the peculiar weather conditions.

Three new fungous plots were this season started on the station bog. One of these (on Howe vines) was sprayed with lime-sulphur solution, made from Frost's Powdered Lime-Sulphur, on June 7, June 18, June 28, July 21 and August 7. This plot was picked on September 28. Its area is 9 square rods, and it yielded 5⅓ bushels, while a check of 6 rods immediately adjacent yielded 12⅔ bushels. The marked decrease on the sprayed area was probably due to some injury caused by the spray. The berries from this plot and its check were tested for keeping quality, the results being in favor of the check, the percentage of loss among the berries of the plot being 34½, while amongst those of the check it was only 25½. As far as the results obtained from this plot are concerned, therefore, there seems to be nothing to be said in favor of this preparation for use as a cranberry fungicide. It is planned to continue this test another season.

Another of the new plots was sprayed with Bordeaux mixture, prepared in the usual way, on June 7, June 17, June 28 and July 21, and with neutral copper acetate on August 7. The area of this plot is 9 square rods and it yielded 7⅓ bushels, while its check of equal area yielded 12 bushels. In the storage tests the loss among the berries from this plot was approximately 17 per cent., while its check showed a loss of 27⅕ per cent.

One-half of the fertilizer plot which had, previous to 1913, been treated the most heavily with nitrate of soda, was also sprayed during the season, for the first time, for the purpose of learning about the combined results of fertilizing and fungous spraying. The spraying with Bordeaux mixture was done on June 6, June 17, July 11 and July 21, and neutral copper acetate was used on August 7. The whole fertilizer plot (plot 15) was picked on September 16, and the sprayed portion yielded only 3½ bushels, while the unsprayed portion gave approximately 6⅓ bushels. In the keeping tests, begun with these berries on October 28 and ended on December 22, the sprayed berries showed a loss of only 31⅖ per cent., while the unsprayed lost 44⅗ per cent.

It will be seen from the figures here given that there was a marked decrease in the fruit production on both of the two new plots treated with Bordeaux mixture and neutral copper acetate. This is in accord with the results generally obtained in the co-operative spraying tests carried on on other bogs by the growers during the season, at least in those tests in which spraying was done during the blooming period. While it is impossible to say definitely what caused the falling off in the fruiting on the sprayed areas, it seems highly probable that the Bordeaux mixture was in some way injurious when used during the blooming period. This can be determined only by further tests.

The new disease, spoken of as the "blossom end rot" in last year's report, was much in evidence, after picking, among the Howe berries of the station bog again this year, most of the rot among those berries being evidently due to it. During the month of October, samples of Howe berries were collected from 54 different bogs, for the purpose of gaining some knowledge concerning the distribution and severity of this disease on different parts of the Cape, as such knowledge seemed not only desirable from the scientific standpoint but also more or less essential for practical purposes. The bogs from which these samples came were distributed as follows: Chatham, 2; Harwich, 4; Mashpee, 1; Falmouth, 1; Nantucket, 1; Wareham, 16; Carver, 7; Marion, 2; Rochester, 2; Plymouth, 3; Middleborough, 2; Pembroke, 2; Hanson (including Bryantville and South Hanson), 11.

The "blossom end rot" was found to be present in varying amount in all the samples collected, and the examinations (made from December 11 to December 15, inclusive) appeared to produce no certain evidence that there is any very distinct sectional variation in the degree of its prevalence among the different portions of the Cape. The largest percentage of loss found to have been certainly caused by this disease, at the time of examination, in any of these collected samples, was roughly 8½ per cent., and the smallest loss found in any sample was roughly 1⅓ per cent. Much of the rot present, however, which did not show the characteristics of this disease definitely was probably, nevertheless, caused by it.

Experiments with Copper Sulphate in the Flowage.

In June, tests were begun looking for the control of fungous diseases on cranberry bogs by the application of copper sulphate in the flowage. These tests were carried out on the flooding sections of the station bog. The strengths of the copper sulphate tried were 1 part to 50,000 parts of water (1 pound in 6,250 gallons) on sections 23 and 25 and 1 part to 100,000 parts of water (about 1 pound in 12,500 gallons) on section 27. The copper sulphate was first dissolved in pails of water, and the solutions were distributed as evenly as possible in the flowage of these sections by throwing them into the flowage by the cupful. This treatment was applied to these sections on June 3 and again on June 16.

On section 23, each treatment was continued about twenty-three hours, the chemical being applied to the flowage within an hour or two after the section was completely flooded. As the whole bog was flooded at the same time that the flooding sections were flowed for this treatment, the vines were more or less wet for several hours before the copper sulphate was put in the water.

On section 25 the treatment was continued for eleven hours and was applied after twelve and one-half hours of complete flooding without treatment.

On section 27 the duration of the treatment was about eleven hours and as with section 25 followed twelve and one-half hours of complete flooding without treatment.

When the first treatment was applied to these sections the blossom buds were well developed and prominent, and when the second treatment was applied they were approaching near to blooming, there being here and there a blossom already opened. The treatment did not appear to affect the buds on sections 25 and 27 injuriously in any way. Some of those on section 23, however, were spotted slightly, showing that the solution used had probably been fully as strong as was desirable.

The strength of the solution used on section 23 was recommended to me by Dr. Shear, as the result of laboratory experiments which he had conducted. Unfortunately, spanworms worked seriously on section 23 and reduced the crop to such an extent as to destroy the results of the experiment so far as the amount of the fruit might give any evidence concerning the effect of the treatment.

At picking time sections 25 and 27 yielded fruit at approximately the same rate as the untreated flooding sections immediately adjacent, while section 23 showed a marked falling off. These sections were picked on September 2.

The berries from all the flooding sections were tested for keeping quality, the period of storage extending from October 29 to December 17. The treated sections 25 and 27 showed little if any improvement over the untreated sections. The berries from section 23 seemed to keep better than those from the other flooding sections, but the difference was not sufficiently marked to justify the conclusion that the copper sulphate treatment had been decidedly beneficial.

4. VARIETIES.

Investigations looking toward the possible development of more desirable and more prolific varieties were continued, especially prolific vines of the late Howe and Vose's Bell varieties being marked for observation next season. Some interesting and apparently valuable sports of the Late Howe variety were also found and were marked. Unfortunately, the majority of the uprights, marked in previous years on account of their prolificness, did not bear well in 1913, though there were a few exceptions.

Samples of the berries of most of the different varieties grown on the Cape were collected in October. Samples of vines were also collected where it was possible to get them without too much trouble. Later these samples were studied more or less carefully, and the varieties which appeared to be mixtures of two or more distinct varieties were separated in a general way into their component parts. From these collected samples smaller samples, numbering in all 180, were taken and bottled in alcohol and formalin for future study and reference. The following are the varieties which were thus sampled, together with the number and general location of the bogs from which samples of each were taken: —

TABLE 4.

Variety.	Number of Bogs from which Samples were taken.	General Location of these Bogs.
Early Black,	1	East Wareham.
Late Howe,	1	East Wareham.
Early Red,	2	Wareham (East and West).
Early Red (?),	1	East Wareham.
Centerville,	2	South Carver and East Wareham.
Perry Red,	1	Marion.
Matthew,	8	East Wareham, Pleasant Lake, Bryantville and South Chatham.
Jersey Berry,	1	West Wareham.
Centennial,	3	Carver.
Champion,	1	Carver.
Mammoth,	2	Bryantville.
Bugle,	5	Santuit, Carver, Bryantville and East Wareham.
Horseneck,	1	Marion.
Berry Berry,	2	Wareham.
Samuel Small's Bugles,	1	Harwich.
McKinley (or Berlin),	1	Chatham.
Cherry Berry,	1	Plymouth.
McFarlin,	5	Carver and East Wareham.
"Howe,"	1	Wareham.
"Howe,"	1	East Wareham.
"Howe,"	1	East Wareham.
Carver Red,	1	Marion.
Unknown Variety,	1	Mashpee.
Vose's Bell (or Pride),	1	Marion.
Shaw's Success,	2	Carver.
Reds,	1	Bryantville.
Smalley's No. 1,	1	East Wareham.
Smalley Berries,	2	South Harwich and East Wareham.
Hocanun,	1	South Hanson.
Aviator,	1	Carver.
North Cape Howe,	1	Wareham.
Leonard Robbins' Berry,	1	Harwich.
Atkins' Seedling,	4	Brewster, Harwich and Plymouth.

Several of the less well known of these varieties, judging from the appearance and condition of the samples when they were examined in January and from the notes obtained when the collection was made, appear to have highly commendable qualities and would probably give a good account of themselves if they were more extensively planted.

5. BLOSSOM POLLINATION.

The plots, from which bees were screened out on the station bog during the blossoming periods of 1911 and 1912, yielded fruit in 1913 at approximately the same rate as the surrounding bog. A new plot was screened off during the 1913 blossoming period with wire netting through which no bee could work its way. There were a few blossoms present when the screen was put in place, but these were all carefully picked off. The crop on this plot was picked on October 8 and amounted to 2¾ quarts, the area of the plot being approximately half a square rod, while the crop produced on any equal area of the surrounding bog was not less than a bushel. It will be noted that this result was in accord with the general results obtained in all similar previous experiments, except that the results with last year's plot were not nearly so striking.

As it was evident at a glance that the margins of the 1913 plot were bearing more berries than its central portion, a margin 9 inches wide was marked off around the plot and picked separately. The total area of this margin was approximately 34 square feet, slightly more than one-fourth of the entire area in the plot, yet it yielded 664 berries, while the whole plot produced only 1,452. A further marked peculiarity noted was that the portion of this margin lying on the upland side of the plot bore much more heavily than did the remainder, the plot being located at the edge of the bog, just across the ditch from the upland.

While these observations seem suggestive, it does not seem that any definite conclusion can be drawn from them.

6. FERTILIZERS.

The station bog plots used in the 1911 and 1912 fertilizer tests were again treated in 1913 with the same kinds and quantities of fertilizer as before. Because of reflowing operations just before the bloom, the fertilizers were applied later than usual, — on July 15. At picking time it was found that the fertilized plots had not, as a rule, produced as many berries as the check plots, the reverse of the result obtained last year. The decrease on the fertilized plots was not very marked, however, except with plots 14 and 15, these being the two plots on which nitrate of soda had been used in the largest quantities. Plot 15 showed a much greater falling off than did 14, and it had received heavier applications of the nitrate than had 14. This result is somewhat surprising in view of the fact that these two plots had by far the heaviest blossom of any portion of the bog. For some reason, however, there was a marked drying up of the blossoms and small berries on these plots, especially on plot 15, not observed to any such extent on other portions of the bog. The conditions were such that, all things considered, this drying up could not very well be laid to dry weather. The reduced fruiting seems to have been due to a detrimental effect of the nitrate, though it is perhaps impossible to say with certainty just what the effect was.

It must be remembered that half of plot 15 was this year sprayed for fungous diseases as well as fertilized, but the unsprayed portion showed a marked falling off in the quantity of fruit as well as the sprayed portion, though the reduction was not so great on the unsprayed part.

All the fertilizer plots were picked with scoops on September 15 and 16. The berries appeared so uniform in color and most other respects that no records were made except those concerning their quantity and size. The average counts of berries in several cup samples taken from each of the plots did not show any considerable differences in size that could apparently possibly be considered to have been caused by the fertilizer.

Storage tests were carried out with berries from all the plots, beginning on October 28 and 29 and ending December 17 to 23, the results of which did not appear to show any marked effect on the keeping quality, attributable to the use of the fertilizers, except with the berries from plot 15. The berries from this plot showed poor keeping quality, due apparently to the excessive use of nitrate of soda. It will be remembered, in this connection, that this plot has received heavier applications of the nitrate than have any of the others.

7. INSECTS.

This year saw a marked decrease in the prevalence of both the flowed-bog fireworm (black head cranberry worm) and the fruit worm. Last year the injury done by both of these insects was abnormally severe as compared with that of most of our recent seasons. This year, however, both insects caused comparatively little trouble, a surprising fact, considering the damage done by them last year. The causes of this year's reduction of these two pests are obscure, but it seems possible that some condition of the weather during some period of the year was responsible for it. If so, the most marked peculiarity noted in these conditions was the very open winter of 1912–13, especially during December and January. Probably the only way in which we can come to any definite conclusion concerning the bearing of weather conditions on the prevalence of these insects is to keep a careful record for a long period of years, and make comparisons of the experiences of one year with those of another.

The season of 1913 has had other peculiarities from the standpoint of cranberry insect troubles, especially in an unusual prevalence of cutworms and of spanworms of several different species. During the season numerous reports came in from cranberry growers, telling of threatening gypsy moth trouble, and the little cranberry snout beetle seemed to be more troublesome than usual.

On August 15, 1912, 42 pupæ of the spanworm, spoken of in last year's report as having done serious damage on the Old Colony bog at Yarmouth, were collected. They were kept on moist sand in cans through the fall, winter and spring. Between June 6 and 15, 33 moths emerged from these pupæ, but no parasites were obtained from them. Three of the pupæ which failed to produce moths appeared to be in good condition and were probably killed by overheating a few days before the moths would have emerged. Of the 33 which emerged, 17 were females and 16 were males. These moths were protandrous in emerging, for before June 11, 13 males and only 8 females emerged, while after June 10, 9 females and only 3 males emerged.

The Old Colony bog was visited on June 13, and the moths of this insect were found to be present in great numbers on an area of about 2 acres (estimated) which had not been treated in any way to get rid of the insect because that portion of the bog belonged to a separate and apparently careless owner. It was estimated that three-fourths of the moths present were males, though the proportions of the sexes were not carefully ascertained. Portions of the bog, which had been heavily infested in July and August, 1912, had been burned over in the latter half of August, and other infested portions had been resanded with seven-eighths to one and one-half inches of sand. Practically no moths of the spanworm were found on June 13 on any of these treated portions, except where the treated areas immediately adjoined untreated heavily infested areas. Evidently the burning had effectively destroyed the pupæ and the sanding had smothered them.

It should be noted that, though the bog had been completely under water for over four months, the winter flowage had not drowned any considerable percentage of the pupæ. This seems remarkable, for they were entirely naked (*i.e.*, were without any cocoon), and they lay fully exposed on the surface of the sand. Practically all of these pupæ found on the bog on June 13 showed distinct signs of life when they were picked up.

At the time of the visit to this bog (June 13) the millers on the infested portion were being caught and eaten (the males mostly, as this sex flew up into the air readily, sometimes as high as 25 or 30 feet, while the females, as a rule, being heavy with eggs and unable to fly well, stumbled and flopped along the ground when attempting to do so) by swallows (two barn swallows and a dozen or more tree swallows). These swallows were flying back and forth like bats, and the clicking of their bills was incessant as they captured the moths.

On June 15 the eggs were dissected out of several plump female moths and counted. These eggs were all bright green in color when fresh from the moth, but they afterward turned yellowish. They numbered 295 in the most productive moth and 187 in the least productive one. Eggs of this insect were found hatching in the laboratory on June 19 and 20.

On July 8 the Old Colony bog was visited again, and the following notes concerning this insect were obtained from Mr. Ellis, the foreman of the bog, who seemed to be a very good observer: —

> The first worms of this insect were found on the bog on June 25. They were then very small. Unhatched eggs were also present in abundance on June 25. Small worms were seen in numbers spinning down the vines and hanging by small silken threads. Most of the moths had disappeared by June 18. The eggs on the vines were yellow and laid in scattering small batches (three to five together). The worms worked first on the backs of the leaves. On June 15 the female moths were more numerous and were scattered more widely over the bog than they were on the 13th, but the males were much less numerous on the 15th than they had been on the 13th. Females full of eggs were abundant on the 15th.

Mr. Ellis had been spraying a considerable part of the portion of the bog that was under his management, and his experience seemed to show that it is not very difficult to control this insect by thorough spraying with arsenate of lead.

On July 8 the worms (of many different sizes) were present on the badly infested portions of the bog in great numbers, the vines having been turned brown by their work and when opened appearing literally alive with them. So little foliage was left on the worst infested portions of the bog that death by starvation for a very large percentage of the worms seemed inevitable.

This insect was also found to be threatening a bog in Mattapoisett this year. Its scientific name is *Epelis truncataria* var. *faxonii* Minot. It has also been found feeding on the bearberry (*Arctostaphylos uva-ursi* L.).

A considerable number of parasites have been reared from the various cranberry pests, the names of which have not yet been determined. Some of these forms appear to represent species new to science. The species which have been named are listed in the following table: —

TABLE 5.

SCIENTIFIC NAME OF HOST.	Common Name of Host Insect.	Scientific Name of Parasite.	Order to which Parasite belongs.	Name of Expert who determined the Name of the Parasite.	Date of Emergence of the Parasite.	Number of Specimens obtained.	Stage of Host's Life-History from which reared.
1. *Peronea minuta* (Rob.),	Dry-bog fireworm,	*Exorista pyste* Walk.,	Diptera,	C. W. Johnson,	September 1 to 10.	10	Pupa.
		Phytodictus vulgaris Cress.,	Hymenoptera,	H. L. Viereck,	August 24, 1906.	1	-
		Pimpla conquisitor (Say.),	Hymenoptera,	H. L. Viereck,	- -	1	-
2. *Mincola vaccinii* (Riley),	Fruit worm,	*Phanerotoma tibialis* (Hald.),	Hymenoptera,	H. L. Viereck,	July 1 to 15.	Very many.	Larva.
		Microbrocon dorsator (Say.),	Hymenoptera,	H. L. Viereck,	July 2, 1907.	1	-
3. *Cymatophora sulphurea* Packard,	Spanworm,	*Ichneumon extrematatis* Cress.,	Hymenoptera,	H. L. Viereck,	- -	1	-
		Euphorocera claripennis Macq.,	Diptera,	C. W. Johnson,	- -	1	-
4. *Calocampa nupera* Lintner,	False army worm,	*Winthemia quadripustulata* F.,	Diptera,	C. W. Johnson,	July 23, 1906.	1	Pupa.
5.	Bud worm,	*Tachina robusta* Town,	Diptera,	C. W. Johnson,	- -	3	-

The Diptera listed in this table are named according to Aldrich's catalogue. Prof. C. W. Johnson of the Boston Society of Natural History has adopted changes in their names as follows: *Carcelia pyste* instead of *Exorista pyste; Phorocera claripennis* instead of *Euphorocera claripennis;* and *Exorista robusta* instead of *Tachina robusta.*

A small Trypetid was reared from cranberries in small numbers last year. Mr. F. L. Thomas, a graduate student at the Massachusetts Agricultural College who is making an exhaustive study of the Trypetidæ of New England, has determined this insect to be a small variety of the apple maggot (*Rhagoletis pomonella* Walsh).

Experimental Insect Work.

The experimental work with insects has been confined mostly to the flowed-bog fireworm (black head cranberry worm) and the fruit worm. The work with these two insects is here discussed in order.

The Flowed-bog Fireworm (*Rhopobota vacciniana* (Pack.)).

In last year's report on this insect, the successful results obtained in the treatment of a certain large bog by holding the winter flowage late (until June 2) and then reflowing about three weeks later to destroy an infestation were fully discussed. A somewhat similar procedure was carried out on another but smaller bog this season with much less satisfactory results, due probably to the fact that the reflowing was done too soon. The results of this treatment, all things considered, seemed, however, to be sufficiently successful to support the belief that where this method of treatment can be applied it will be found at least a fairly satisfactory one. The reflowage should evidently be continued for about forty-eight hours in this treatment.

The ideas advanced in last year's report, as to the way in which the bunching up of the hatching of the eggs of this insect is brought about by the late holding of the winter flowage, were evidently erroneous, as shown by observations made this year. Tests with thermometers made during the June reflows of the station bog showed that there are greater differences of temperature among the vines of a cranberry bog when the bog is flowed than when it is open to the air, the conditions in this respect being exactly the reverse of what they were last year presumed to be. It now seems probable that the bunching of the hatching by the late holding of the water is brought about mostly by a retardation or prohibition of hatching for the first eggs that reach or approach the hatching stage. It seems evident that the worms from any eggs, which might become far enough advanced to hatch under water, would drown soon after hatching, and it is not impossible that this is what really happens to the eggs soonest developed while the eggs of slower development are catching up with them as the warming up of the water in the late spring allows them to develop. It is, of course, evident that the whole hatching process is naturally more rapid under the hot sun of June than it is when the development of the eggs and their hatching takes place in the cooler weather of the first half of May, as usually occurs when the winter flowage is drawn off early.

The general position taken in last year's report in regard to the practice of spraying for this insect should probably be maintained. It seems possible, however, that instead of using Bordeaux mixture and Paris green for this spraying it will be found best to use arsenate of lead alone, for while some of the results with Bordeaux mixture have been satisfactory, there seem to be indications, as hinted in the discussion of the fungous work, that it may be, under some conditions at least, an injurious spray to use. Experiments are planned to find out more exactly about this. On some bogs where Bordeaux mixture and Paris green were used on one part and arsenate of lead on another, this year, the arsenate seemed to give rather distinctly better results.

We have not yet learned what is the best method of applying a spray to a cranberry bog. There is considerable diversity of opinion and experiments are planned along this line. It seems probable that in thick vines a spray driven with a good deal of force will place poison where it will have a more satisfactory effect in destroying this insect than will the poison of a spray lightly applied.

From observations made on a considerable number of bogs this year the fireworm seems to be distinctly more injurious on vines of the Late Howe variety than on those of the Early Black, and it seems probable that the late Howe is a favorite variety with the pest. If this is the case it is only an added indication that where bogs are being newly built it is the part of wisdom to plant only one variety on a bog. It is now becoming generally recognized that the planting of several varieties together on the same bog causes more or less serious inconvenience in many ways.

A detailed account was given in last year's report concerning the parasites and other natural enemies of this insect and concerning the bearing which bog flooding has upon their effective activity. In connection with this, attention should have been drawn to the fact that when a bog is reflowed after picking, the most conspicuous forms of animal life that are driven ashore by the water, from the standpoint of their numbers, are the spiders. The number of these forms seen by one looking for them on the occasion of such after-harvest reflowing is really surprising, and it is interesting to note that most of them, even on a bog of considerable size, succeed in reaching the upland alive, as they are fitted to float lightly upon the surface of the water for considerable distances if need be. In all his examinations of bogs made during the process of the after-harvest reflow the writer has as yet failed to see a sufficient number of parasitic insects driven up by the water to lead him to believe that they can have nearly as important a bearing on the prevalence of the fireworm as do the spiders. It is probable, however, that the presence of the parasites on a bog is, in a sense, more affected by the flowing than is that of the spiders, because they are probably far more liable to destruction by drowning than are the spiders, and, moreover, the parasites affecting the fireworm are probably more or less peculiar to it, while its spider enemies are presumably not so to any considerable extent.

The Fruit Worm (*Mineola vaccinii* (*Riley*)).

The chief work of the year with this insect has been a study of its natural enemies. Nearly a dozen species of its parasites have now been reared, and the complete life-history of the most important one was worked out in a general way. The connection of this parasitic insect with the fruit worm has not been heretofore suspected. Mr. H. L. Viereck, an expert on the group of insects to which it belongs, has determined it to be a Braconid, to which has been given the name *Phanerotoma tibialis* (Haldeman). This insect is seen on the cranberry bogs in large numbers every summer during and after the blooming period, but its presence has not been accounted for until now. This year it was seen in greatest numbers during the first three weeks of July. The adults had almost entirely disappeared from the bogs by July 26, it being possible to find only now and then one on that date.

A large number of wormy berries were collected during August, 1912, and kept in cans until Aug. 1, 1913. A careful record was made both of the moths and of the parasites which emerged from them. The wormy berries used in this investigation came from three general locations, as follows: —

1. The center of a flowed bog (station bog).
2. The edge of a flowed bog (station bog).
3. A dry bog (that is, one not flowed at any time).

The record of moth and parasite emergence was kept with these locations in mind. The most interesting points brought out by the record thus obtained were: —

1. That *Phanerotoma tibialis* far outnumbered all the other parasites taken together. All the parasites obtained from the berries collected at the center of the station bog, and all but one of those from the berries from the edge of this bog, were of this species. About four-fifths of the parasites from the berries collected from the dry bog were also of this species, but the percentage of other species of parasites was much greater among the forms obtained from the dry-bog berries than among those from the berries of the flowed bog.
2. The berries from the dry bog produced nearly three times as many parasites in proportion to the fruit-worm moths which emerged, as did the berries from any portion of the flowed bog.
3. The time of the greatest emergence of the parasites, from the berries from all three locations mentioned, was from June 30 to July 9, inclusive.
4. As slightly more parasites than moths emerged from the worms of the berries from the dry bog, it seems highly probable that more than 50 per cent. of the fruit worms on that bog last year were killed by these parasites. This shows something of the importance of the natural enemies of this insect which we have been in the habit of considering as being comparatively free from parasites.

It will be observed that the relative number of parasites obtained from the flowed bog and from the dry one shows a similar condition, as regards the amount of parasitism present on dry and flowed bogs, as that which has already been found to prevail with the natural enemies of the fire-worm. From a study of the life-history of *Phanerotoma tibialis*, however, it is not easy to see just how the flowage can affect its prevalence to so marked an extent.

It was found that the adult *Phanerotoma* lays its egg in the egg of the fruit worm. It was not difficult to get one of these parasites to lay its egg under observation, by bringing near it a berry bearing, under one of the lobes of its blossom end, an unhatched fruit-worm egg. During their laying season these parasites are constantly running over the vines with actively vibrating antennæ, searching for the eggs of the fruit worm, and when a fruit-worm egg is presented to one of them, if the parasite's antennæ sense its location, it will give immediate attention to it, and the whole process of egg-laying may be observed. A peculiar fact discovered was that one of these parasites will never lay twice in the same fruit-worm egg. One of them can, however, be readily induced to lay an egg in a fruit-worm egg which already contains one or even several (twelve was the highest number reached in any test) eggs deposited by other individuals. It is not known whether the egg of the parasite hatches before the fruit-worm egg does or not, but at any rate the fruit worm when it emerges from the egg carries the small parasite with it, and as the fruit worm grows, the parasite within it also grows, feeding upon its juices and so depleting its vitality that when it becomes full grown and forms a cocoon around itself for the winter it is often but little more than half the size of a normal unparasitized worm. Some time during the winter or spring the parasite larva becomes full grown, and, emerging from the fruit worm, leaves it a mere dead shell, and forms its own tiny white cocoon about itself within the cocoon of the fruit worm. Within its cocoon it changes into the pupa stage, and it eventually emerges as an adult parasite nearly a year after it was deposited as an egg in the egg of the fruit worm.

The second most important parasite which was reared is a small Ichneumon, which lays its egg in the fruit worm after the worm has hatched and is already working in the berry. The name of this species has not yet been determined. The female in laying its egg inserts its egg-laying apparatus into the hole in the berry made and left open by the fruit worm. This parasite was never seen to drive its egg-laying apparatus through one of the white silken curtains which the worm usually makes over the mouth of its hole after going into its first or second berry. The life-history of this parasite has not yet been worked out to any extent. It is certainly a far less important enemy of the fruit worm than is *Phanerotoma tibialis*.

A large quantity of wormy berries was collected in August for the purpose of making a detailed study of some of the immature stages of these parasites, particularly of *Phanerotoma tibialis*.

Study of Control for Flowed Bogs.

No very definite advance in our ideas concerning the control of this pest by flooding was made during the year. The recommendations given in last year's report still stand with no substantial alteration. It was suspected that the depth of the flowage had some bearing on its effect in killing the worms within their cocoons, as it seemed reasonable to suppose that the greater water pressure of a deep flowage would be more effective in collapsing or penetrating the cocoons than would be the slight pressure of a shallow flowage. To test this, different lots of fruit worms, spun up naturally in their cocoons, were submerged to various depths in water contained in long glass tubes 2 inches in diameter. The following table, showing the results of some of these tests, is self-explanatory: —

Table 6.

Date submerged.	Date taken from Water.	Number sub-merged.	Depth of Submer-gence (Inches).	Cocoons occupied after Submer-gence.	Cocoons unoccu-pied after Submer-gence.	Number of Worms found Alive.	Number of Worms found Dead.
Oct. 8, 6 P.M.	Oct. 17, 5 P.M.	12	19	10	2	10	-
Oct. 8, 6 P.M.	Oct. 17, 5 P.M.	12	40	11	1	10	1 (?)
Oct. 8, 6 P.M.	Oct. 17, 5 P.M.	12	56	12	-	10	1[1]
Oct. 8, 6 P.M.	Oct. 17, 5 P.M.	12	68	12	-	10	2
Oct. 8, 6 P.M.	Oct. 17, 5 P.M.	9	80	9	-	8	1

It will be seen from this table that nine days of submergence, after the 8th of October, appeared to have but little effect on the worms at any depth tested. The remaining tests, not recorded in this table, gave results entirely similar. Possibly submergence earlier in the season would have been more effective in killing the worms. Bogs bearing late varieties could probably not, however, as a rule, be reflowed, after picking, before September 25, and it hardly seems probable that a difference of two weeks in the season would be sufficient to cause any marked difference in the effects of submergence on this insect. It may, of course, be possible to work in a flooding between the picking of the early and of the late varieties, but general experience appears to cast doubt upon the advisability of such a program.

An interesting fact learned while making these submergence tests was that the cocoons of the fruit worm are not at all impervious to water. When carefully opened, after only a few minutes' submergence, they were found to be wet inside, the water having apparently penetrated them almost immediately. It now seems evident that the cocoon protects the

[1] And 1 doubtful.

worm by preventing the escape of the vesicle of air which it contains, which the worm needs more than anything else in order to survive, rather than by keeping out the water by any imperviousness of its texture.

Study of Control for Dry Bogs.

The sanding experiment conducted last year to determine whether this insect could be smothered in its cocoon was repeated and continued this year on the same heavily infested bog, but the general results were unsatisfactory. It now seems pretty certain that this method of treatment for this insect will never be practicable.

In last year's report suggestions were made concerning the possibility of starving out fruit-worm infestations on dry bogs by killing the remnant of the bloom, in seasons of severe winter-kill injury or of severe frost damage, by spraying with a 20 per cent. solution of iron sulphate. First tests of the practicability of this method of treatment were made this year, and it was found that this solution can be used in such a way as to kill the bloom without apparent injury either to the vines or to the buds forming for the succeeding year's growth. It was necessary, however, to apply three rather thorough sprayings to accomplish the entire destruction of the blossom, because of the fact that the blossoming does not all take place at one time but is extended through a period of three or four weeks. The necessity of three sprayings instead of one has brought in a new element of danger which must be considered in connection with the practicability of this treatment. In making the 20 per cent. solution of iron sulphate 100 pounds of the chemical are used to every 50 gallons of water. It takes not less than 150 gallons to spray an acre thoroughly. This means that with each application 300 pounds of the iron sulphate would be put on each acre. Three applications would therefore deposit nearly half a ton of this chemical, per acre, on the bog. It seems probable that this amount of iron sulphate might injure the cranberry root system and perhaps kill the vines. Further experiments to determine about this are planned. If there proves to be no danger in this way, it seems probable that this method of treatment may be used to advantage on dry bogs.

8. WEEDS.

Horse-tail (*Equisetum* spp.) is one of the most troublesome weeds with which the cranberry grower has to contend. In general the growers show more concern over this weed than they do about any other. For this reason some attention was given to experimenting with it during the year. Solutions of copper sulphate as strong as 1 pound to 25 gallons of water were injected into a bog where this weed was growing in abundance to depths ranging from 6 inches to 2 feet, the solution being poured into holes a foot apart each way, made with a crow bar, a quart of the solution being used in each hole. Unfortunately, this treatment did not seem to affect the horse-tail injuriously, but rather seemed to cause it to thrive instead.

Thorough spraying with a 20 per cent. iron sulphate solution was fairly effective in killing back the tops of the weed, but there is, as has been already noted under the fruit-worm discussion, a possible danger connected with the continued use of this chemical on the same area.

9. RESANDING.

Plots O and V, spoken of in last year's report, were again left without resanding this year, while the surrounding bog was also not resanded. Three new plots, N, R and T, were laid out and resanded on Oct. 17, 1912, while the surrounding bog was not resanded again. All these plots were picked with scoops in 1913, and checks on each were laid out and picked for comparison. The following table is, in this connection, self-explanatory: —

TABLE 7.

PLOT.	Area of Plot (Square Rods).	Date picked.	Quantity of Fruit obtained (Bushels).	Percentage of Loss in Storage Tests.	Variety.
O,	9	Sept. 8	12 1/2	29 2/5	Early Black.
O (check 1),	9	Sept. 8	15	28 9/10	Early Black.
O (check 2),	9	Sept. 8	19 1/2	–	Early Black.
V,	9	Sept. 6	18 1/6	36 3/4	Early Black.
V (check 1),	9	Sept. 6	22	41 2/10	Early Black.
V (check 2),	9	Sept. 6	18 2/3	–	Early Black.
N,	9	Sept. 4	20	38 1/4	Early Black.
N (check 1),	9	Sept. 4	15 1/6	30 1/7	Early Black.
N (check 2),	9	Sept. 4	25	–	Early Black.
N (check 3),	9	Sept. 4	23 1/2	–	Early Black.
R,	9	Sept. 9	17	36	Early Black.
R (check 1),	9	Sept. 9	16 3/4	34 2/10	Early Black.
R (check 2),	9	Sept. 9	18	–	Early Black.
T,	9	Sept. 28	20 1/2	38 3/4	Howe.
T (check 1),	9	Sept. 28	19	29 2/5	Howe.
T (check 2),	9	Sept. 28	23	–	Howe.

It will be seen from the above table that plots O and V showed a distinct falling off in quantity of fruit, due to the prolonged lack of resanding. Plots N, R and T, however, gave no increase in fruit over their checks, probably because the previous resanding of the general bog (fall of 1911) was still sufficient to maintain the vines in very good condition. Berries from all these plots and their checks were tested for keeping quality, the period of storage extending from October 28 to about December 20 on the average, there being a variation of five days in the time of final screening, with the results given in the above table. The berries of the checks on each plot were mixed so as to have a single storage check in each case. The check storage figures given in the table, therefore, represent the mixture rather than the first check alone with which they are in each case associated. As the table shows, the berries of the unsanded plots, O and V, kept somewhat better on the average than did those of their checks, while the berries of the sanded plots, N, R and T, all showed a poorer keeping quality than did those of their checks. The results of these tests, therefore, substantiate the findings of last year.

10. MISCELLANEOUS.

During the fall the possibility of introducing cranberry vines for holiday decorations for dining rooms was investigated. A patch of Late Howe vines was left unpicked and was so protected from frost until into November, by covering with canvas, that it kept in good green condition. Some of these vines were cut and several wreaths and other decorations, bearing the natural fruit, were made from them, a damp moss foundation being used in every case. From the standpoint of beauty these decorations probably could not be easily surpassed, and there seemed for a time to be a considerable promise of success for them. It was found eventually, however, that even though plunged in wet moss the vines did not endure the heat of warm rooms for more than two or three days before they deteriorated badly in appearance. It became evident, therefore, that cranberry vines could not be used successfully in this way. Possibly, however, a satisfactory decoration could be made up by putting them in gold-fish jars for table ornamentation.

The results of the following spraying tests are of general interest, the spray in every case having been applied on a cranberry bog on the 29th of July: —

1. Plot sprayed with a mixture made up as follows: copper sulphate, 2 pounds; lime, 1½ pounds; resin fish-oil soap, 1 pound; arsenate of lead, 3 pounds; water, 25 gallons. No injury was later observed to have been caused by the application of this spray.

2. Plot sprayed with a mixture made up as follows: lime, 1½ pounds; resin fish-oil soap, 2 pounds; arsenate of lead, 3 pounds; water, 25 gallons. No injury was observed as a result of this application.

3. Plot sprayed with the following mixture: resin fish-oil soap, 2 pounds; arsenate of lead, 3 pounds; water, 25 gallons. The vines on this plot were badly burned by the treatment.

The interesting point shown by these three tests is that resin fish-oil soap and arsenate of lead cannot safely be used together as a spray unless lime is added. This confirms the general result of tests made in previous years, but not reported upon.

A plot was picked by hand in the three years 1911, 1912 and 1913 successively, the quantity of fruit it produced in comparison with the surrounding bog being carefully noted each year, the general result being that no distinct advantage was shown for hand picking, from the standpoint of the quantity of fruit obtained.

The Station Bog Crop.

The bog bore a heavy crop this year, averaging about 100 barrels to the acre. This was probably largely due to the rest which the vines obtained because of last year's light crop. More water was pumped for irrigation this year than in 1912, but on the whole the bog was nevertheless run fairly dry throughout the season, the ditches not being held full of water for more than a day or two at a time. There is probably a limit beyond which a bog may become too dry if it is not irrigated. It seems probable that the wisest course to pursue, in irrigating a bog during the growing season, is to try to be sure that it has what water it needs, but that it is not given moisture much in excess of its needs. It is probably better to give a bog a good wetting occasionally and then draw off the surplus water, so that the ditches shall be fairly empty, than it is to keep the ditches full for any considerable period of time during the growing season and so run the risk of injuring the root system. The year's observations have confirmed those of last year in showing that the higher and better drained portions of a bog usually produce more fruit than the low portions. Blocks of vines from different parts of flowed and dry bogs were cut out during the season, and their root systems were washed out and examined, it being discovered from this that, while on dry bogs there is often a well-developed root growth running deep into the peat, the root system of flowed bogs is apparently always confined for the most part to the sand above the peat. It seems likely that this condition on the flowed bogs has been brought about by root drowning caused by holding the water table too high during periods of root growth. A mere examination, therefore, of the amounts of fruit borne by high and low portions of a bog is probably not sufficient to justify any certain conclusion concerning the causes of differences noted in the amount of fruit produced, for while a season's drainage is one possible important factor, the development of the root system, brought about by the conditions of previous seasons, is perhaps as likely to have a powerful influence on the ability of the plant to withstand drought, and therefore produce fruit under extreme conditions.

A Needed Investigation.

We are coming to understand something of the factors bearing directly on the portion of the cranberry plant which is above ground. While it is important to understand these more easily observed agencies bearing on the welfare of the plant, it seems certain that some of the most important things which influence cranberry growth and fruiting have been almost entirely neglected in our studies up to the present time. A knowledge of the special physiology of the plant, especially of the development and activities of its root system, seems to be very greatly needed. The seasonal development of the root system of most plants begins fairly early in the spring and is nearly coincident with the development of the portions of the plant above ground. Recent investigations [1] by Professor Coville, of the Bureau of Plant Industry of the United States Department of Agriculture, have shown that with the blueberries, which are closely related to the cranberry, there is no new root growth until the plants have developed both their leaves and their blossoms. If this is also the rule in the development of the cranberry, it may have a rather vital bearing on the practices to be observed in the flooding and irrigation of cranberry bogs. A lot of vines have already been potted in earthen pots for this and other studies, and it is planned to pot more in glass pots, so that the growth of the root system may be directly observed in all its stages and in all seasons.

NOTES ON THE WATER OF CRANBERRY BOGS.[2]

Since 1910 the experiment station has been studying the properties and movements of the water in cranberry bogs, in order to determine the probable losses of fertility in the drainage water, because the bogs are generally flooded throughout the winter and sometimes for brief periods during the summer, as a protection against frost and insects.

The problem of fertilizing cranberry bogs to improve the crop is complicated by this periodical flowage and drainage. Many cranberry growers think that fertilizers are wasted if applied to the bogs, while actual field experiments in Massachusetts, New Jersey and Wisconsin have shown a positive benefit by a light top-dressing of soluble chemicals, namely, nitrates, superphosphates and potash salts.

The small experimental cranberry bogs in which the studies have been made were devised by Director Brooks, who has described them fully elsewhere.[3] It is deemed sufficient for this article to say that each bog is contained in an upright cylinder 24 inches in diameter and 48 inches in depth, constructed of glazed sewer tile bedded in concrete. Each bog is connected by a brass pipe passing through the concrete, with a smaller cylinder of similar construction, 6 inches in diameter and of the same depth as the bog. The small tile corresponds to the drainage ditch in the field, and is provided with an outlet and stopcock 12 inches below the level of the surface of the bog. By means of the smaller cylinder the bog can be drained or irrigated at will, and the depth of the water-level below the surface can be observed at any time.

At the approach of winter the bogs are fitted with galvanized iron rims cemented in place with an asphaltum cement, by which the water-level over the bogs may be raised to a height of about 12 inches. To prevent freezing and bursting the cylinders the entire set of bogs is covered with a

[1] Experiments in Blueberry Culture," by Frederick V. Coville, 1911. Bulletin No. 193 of the Bureau of Plant Industry, United States Department of Agriculture.

[2] By Fred W. Morse.

[3] Proc. Soc. Promotion Agri. Sci., 1911, pp. 23-28.

removable roof of boards which is further covered by cornstalks and hay to a depth sufficient to completely protect the interior from external temperature. As soon as freezing weather is over in the spring the covering of litter is removed, and later, at the proper season for draining the bogs, the roof is taken away.

The drainage from a cranberry bog consists of two quite distinct portions, namely, the run-off from the surface and the seepage from the soil, while there is the ditch water at the beginning of drainage, which is a mixture of both kinds. On a properly graded bog nearly all the surface flowage should run directly into the ditches without seeping through the soil. On the other hand, water retained by the vines and in depressions in the surface of the bog, together with the water held in the pore-space of the sand and peat above the level of the sluice gates, must either evaporate or sink lower into the bog, and as it settles it displaces the saturated bog water, which seeps into the ditches.

The composition of the three types of drainage water has been carefully followed season by season, and it is believed that some light has been obtained on the probable losses of fertility.

The surface water is removed from the experimental bogs by means of a dipper, because their construction does not permit it to be drawn off otherwise without losing its identity. Its composition has been found to be essentially like any surface water from ponds and streams. The surface waters from four bogs that had been top-dressed with a complete fertilizer in 1911 were examined in the spring of 1912, in comparison with the surface water from four bogs which had received no fertilizer. Total solids and organic solids were first determined with the following results: surface water contained in 100,000 parts, 16.0 parts total residue and 4.8 parts organic matter from the fertilized bogs while the surface water from the unfertilized bogs contained 19.2 parts total residue and 6.4 parts organic matter. No nitrates were found, and as the fertilized bogs had not imparted any increase of soluble matter to their flood waters it was not deemed worth while to carry the analysis further. The run-off cannot be considered as removing from the bogs any serious amount of fertility, since its composition cannot vary widely from the water when applied, except for the soluble matter that is extracted from the vines.

The water standing in the small cylinders at the time the surface water was dipped from the bogs is nearly the counterpart of the ditch water after the run-off has past and seepage begins. That is, it is a mixture of surface water and seepage water. A number of analyses have been made of the water at this stage, because there are possibilities for considerable variation, and it will be noted in the table that there is a wide range between the two seasons.

Table 1. — *Composition of Ditch Water.*

[Parts in 100,000.]

Bog.	May 4 and 9, 1912.		
	Total Residue.	Organic Matter.	Total Nitrogen.
8 (A and B), ...	71.1	38.6	1.42
9 (A and B), ...	64.3	33.6	1.38
14 (A and B), ...	56.2	26.2	1.15
15 (A and B), ...	52.3	26.3	1.36

Bog.	May 8 and 9, 1913.			
	Total Residue.	Organic Matter.	Total Nitrogen.	Potash.
4 (A and B), ...	37.0	12.2	0.28	-
5 (A and B), ...	38.0	11.4	0.40	3.8
6 (A and B), ...	40.4	10.8	0.56	3.1
7 (A and B), ...	56.2	15.2	0.90	4.6
8 (A and B), ...	60.6	14.4	0.91	4.7
9 (A and B), ...	46.8	13.0	0.45	3.6
10 (A and B), ...	65.2	17.4	0.56	-
12 (A and B), ...	56.8	15.8	0.91	-

To estimate the probable losses from a bog it would be necessary to know the capacity of the ditches, since the small cylinders in our experiments bear a much larger proportion to the bog's surface than occurs in field practice.

The average content of nitrogen in the ditch water was 1.33 parts in 100,000 in 1912, and 0.62 part in 100,000 in 1913. Potash was determined only in 1913, when the average content was 3.96 parts in 100,000. Fifty thousand gallons of ditch water, containing 0.98 part of nitrogen and 3.96 parts of potash in 100,000 parts of water, would carry away a trifle more than 4 pounds of nitrogen and 16 pounds of potash. It would also be equivalent in volume to the water contained in a ditch 3 feet deep, 2 feet wide and a little over 67 rods long, which would be more ditch than is usually employed on an acre of cranberry bog.

The mixture of surface and seepage water in the small cylinder of the experimental bogs may or may not closely resemble similar water in the ditches of large bogs. It is the writer's opinion that the latter water would be even more dilute, since a sample of ditch water collected at the experimental bog in East Wareham contained only 21.3 parts of total solids and 12.1 parts of organic solids in 100,000 parts of water at a time when Dr. H. J. Franklin, the superintendent of the bog, deemed the ditch water to be at its normal state, with no irrigation water mixed with it. There was but 0.28 part of total nitrogen in 100,000 parts, and bare traces of phosphates and potash in this water.

The seepage water, which is practically the same thing as the saturated soil water from the interior of the peat, is noticeably uniform in composition throughout the season, and the average composition for 1912 is very close to that of 1911, published in the twenty-fourth annual report.[1]

TABLE 2. — *Composition of Seepage Water, 1912.*

Total Residue and Organic Matter.

[Parts in 100,000.]

Bog.	May 14.		May 22.		June 10.		June 17.	
	Total Residue.	Organic Matter.	Total Residue.	Organic Matter.	Total Residue.	Organic Matter.	Total Residue.	Organic Matter.
8 (A and B),	101.0	53.0	114.8	52.0	-	-	109.4	60.6
9 (A and B),	91.4	50.6	118.4	54.2	-	-	114.0	63.4
10 (A and B),	119.4	62.8	144.5	75.1	-	-	132.0	74.4
12 (A and B),	95.0	51.0	111.4	51.4	113.0	62.8	-	-
13 (A and B),	98.6	52.0	124.2	59.2	91.8	63.4	-	-
14 (A and B),	102.0	50.2	137.2	76.0	134.6	67.2	-	-
15 (A and B),	105.5	54.4	122.1	62.7	104.2	57.2	120.0	67.4

Fertility Constituents.

[Parts in 100,000.]

Bog.	Total Nitrogen.					Phosphoric Acid.		Potash.	
	May 14.	May 22.	June 10.	June 17.	June 25.	May 22.	June 10.	May 22.	June 10.
8 (A and B),	2.45	3.04	-	2.66	-	-	-	-	-
9 (A and B),	2.13	3.08	-	2.52	-	-	-	-	-
10 (A and B),	3.01	3.96	-	3.36	3.38	-	1.78	7.75	-
12 (A and B),	2.27	3.15	2.94	-	3.05	1.19	1.55	7.44	-
13 (A and B),	2.38	3.22	2.90	-	2.69	1.17	-	7.29	6.15
14 (A and B),	2.27	3.32	-	-	3.01	1.14	1.48	-	8.12
15 (A and B),	2.59	3.43	3.32	2.73	-	-	2.00	-	6.62

[1] Mass. Agr. Sta., 24th An. Rept., Pt. I., p. 220.

The amount of this seepage must vary from season to season. The spring seasons of 1912 and 1913 were unusually wet for about three weeks after the surfaces of the bogs were drained, and several rains made it necessary to open repeatedly the stopcocks in the drainage cylinders. The amount of seepage determined by the amount of water which flowed through the outlets amounted to 25.6 quarts per bog in 1912 and 24.5 quarts in 1913, or, in round numbers, a little over 90,000 gallons per acre in the first year and over 85.000 gallons in the second, or an average weight of over 700,000 pounds of water per acre, which would contain, discarding fractions, more than 21 pounds nitrogen, 10 pounds of phosphoric acid and 50 pounds of potash.

There was no evidence that the application of fertilizers in the previous year caused any increase in these substances.

Fertilizer Scheme for Bogs.

Bogs numbered 6, 10, 11 and 14 receive no fertilizers.
Bog numbered 1 received nitrate of soda.
Bog numbered 2 received acid phosphate.
Bog numbered 3 received sulfate of potash.
Bog numbered 4 received nitrate and phosphate.
Bog numbered 5 received nitrate and potash.
Bog numbered 7 received phosphate and potash.
Bogs numbered 8, 9, 12, 13 and 15 receive all three substances.

The period of seepage was succeeded in both seasons by a short space of time during which the water-level fluctuated within narrow limits, and following this interval was a prolonged dry season during which it was necessary to add water repeatedly to the small cylinders to replace the amount of water evaporated from the surface of the bogs. The addition of this water gradually changed the composition of the water in the cylinders until it showed that practically all of the original seepage water had been reabsorbed by the peat. This showed that there was no apparent diffusion from bog to cylinder, and there must be actual movement of water from the bog to cause any loss to the bog of its soluble matter.

The permanent losses of fertility are limited to the seepage water which actually flows away from the ditches into the main drain or stream passing through a bog. They cannot be avoided; but there is no evidence that the small additions of chemicals in the late spring increase the losses any.

The amount of water required for irrigation was determined in both years by measuring the quantities added from time to time to the small cylinders. These cylinders were kept covered with galvanized iron caps, so that evaporation and rainfall would affect only the surface of the bogs. Water was added on seven different dates in the summer of 1912, beginning with July 3 and ending on August 16. In 1913 there were eleven different dates, beginning with June 19 and ending on August 28.

The total amount added in 1912 was 13.75 gallons per bog, equivalent to a depth of 7 inches over the surface, while in the yet drier season of 1913, 23.75 gallons were required per bog, or a depth of 12 inches.

During 1912 it was noticeable that some bogs evaporated much more rapidly than others; but the actual differences were not determined. In the fall, before putting on the sheet-iron rims, it was necessary to cut off the vines which extended over the wall of the tile, and also to cut out some of the surplus growth within the bog area. These prunings were dried and weighed, and were found to vary much. There also appeared to be some relationship between the weight of prunings and the rate of water movement in the bogs, which was to be expected, since transpiration should increase with the development of the vines.

Therefore in 1913 a careful record was kept of the amounts of water removed from individual bogs as drainage water in the spring and the quantities of irrigation water added during the summer. The results, together with the weight of vines removed the previous fall, are given in Table 3, as follows: —

TABLE 3. — *Relation between Drainage, Irrigation and Vine Growth.*

Bog.	Drainage (Quarts).	Irrigation (Quarts).	Vines (Grams).	Bog.	Drainage (Quarts).	Irrigation (Quarts).	Vines (Grams).
6A, . .	25.1	88.0	190.7	6B, . .	21.5	103.0	184.2
10A, . .	21.0	98.0	187.1	10B, . .	28.5	107.0	295.8
14A, . .	19.5	95.0	185.2	14B, . .	18.4	85.0	140.5
11A, . .	3.1	64.0[1]	38.0	11B, . .	23.5	96.0	184.3
2A, . .	28.9	102.0	123.2	2B, . .	30.0	113.0	221.7
3A, . .	24.5	100.0	165.4	3B, . .	28.9	120.0	238.9
7A, . .	22.9	85.0	124.1	7B, . .	28.2	114.0	298.3
1A, . .	10.8	85.0	98.5	1B, . .	6.4	62.0	91.4
4A, . .	32.0	117.0	258.9	4B, . .	31.3	117.0	302.1
5A, . .	28.1	101.0	213.9	5B, . .	23.3	96.0	216.6
8A, . .	23.6	89.0	186.8	8B, . .	25.6	98.0	226.6
9A, . .	23.3	83.0	187.8	9B, . .	24.8	93.0	221.8
12A, . .	27.1	100.0	252.5	12B, . .	28.3	103.0	235.4
13A, . .	25.3	92.0	173.3	13B, . .	25.6	93.0	214.3
15A, . .	30.9	93.0	231.2	15B, . .	22.9	85.0	173.0

Excluding 1A, 1B and 11A, the averages for 27 bogs are: drainage, 25.6 quarts; irrigation, 98.7 quarts; vines, 208.8 grams.

The bogs are arranged so that the unfertilized ones, 6, 10, 11 and 14, head the columns, followed by 2, 3 and 7 with no nitrogen, while 1, 4 and 5 receive nitrogen in nitrate of soda, and 8, 9, 12, 13 and 15 are dressed with complete fertilizers, including nitrates.

It will be noted that neither nitrogen nor other fertilizers were responsible for large vine growth, but that in 12 out of 14 bogs having vine

[1] Water applied to surface of bog.

growth above the average, the drainage from the bogs in the spring was above the average, and in 10 cases the irrigation was high also. On the other hand, bogs 1A, 1B and 11A, in which the water movement was notably slow, yielded the smallest weights of vines when pruned.

In a large proportion of the bogs the growth of vines appeared to be related to the freedom with which the soil permitted the water to move from bog to drain and back again. Not only was more water evaporated during the summer, but these bogs permitted rapid percolation or seepage in the spring into the small cylinders. The bogs with small vine growth were slow to drain in the spring, and much of the water evaporated from the surface of the bog instead of seeping into the drainage cylinder.

In conclusion our observations show that the principal losses of fertility are in the seepage water which may escape from the ditches, and that the vine growth is more influenced by the free movement of water than by fertilizers.

The assistance of Mr. R. W. Ruprecht in measuring the water, and of Mr. R. L. Coffin in pruning and weighing the vines, is gratefully acknowledged.

THE DETERMINATION OF ACETYL NUMBER.[1]

EDW. B. HOLLAND.

Introduction.

The various hydroxy compounds that occur in oils, fats and waxes form derivatives on heating with acetic anhydride, the acetyl radical displacing the hydrogen of the alcoholic hydroxyl groups. This property serves as the basis of analytical methods for the quantitative determination of these compounds. The proposed acetyl number indicates the milligrams of potassium hydroxide required for the saponification of the acetyl assimilated by one gram of an oil, fat or wax on acetylation.[2] On saponifying with alcoholic potash the acetyl is hydrolyzed to acetic acid and combines with the alkali to form potassium acetate. The results are expressed in terms of milligrams of potassium hydroxide to conform with the general practice in fat analysis. The compounds involved are monohydroxy and dihydroxy acids and their glycerides, — monoglycerides and diglycerides and free alcohols.

Use of the Test.

In the examination of oils and fats a determination of acetyl number is necessary, in most instances, for a thorough understanding of the nature and quality of the product. Some of the hydroxy compounds are natural and others are the result of hydrolysis or of oxidation. Glycerides of hydroxy acids are a natural constituent of certain oils and fats, although they do not appear to be very widely distributed in any considerable amount. Castor oil, composed largely of ricinolein, is a notable illustration. Hydroxy acids probably occur more frequently as the result of oxidation of unsaturated acids. Oleic acid has been shown repeatedly to be comparatively unstable. By the assimilation of oxygen and water it may be converted into dihydroxystearic acid, a saturated compound.

$$C_{17}H_{33}COOH + H_2O + O = C_{17}H_{33}(OH)_2COOH.$$

Whether the oxidation takes place in the glycerides or in the fatty acids after hydrolysis is uncertain, although the latter appears the more probable supposition.

Monoglycerides and diglycerides result from the hydrolysis of triglycerides, and free fatty acids condition their presence. The absence of

[1] The writer is pleased to acknowledge many suggestions and helpful criticisms by Dr. J. S. Chamberlain, Mr. F. W. Morse, Mr. J. C. Reed and Mr. J. P. Buckley.

[2] Benedikt and Ulzer, and Lewkowitsch report on the basis of the acetylated product.

free fatty acids in a commercial product, however, does not necessarily preclude the presence of monoglycerides and diglycerides.

Solid alcohols of the cyclic series (sterols) occur in oils and fats both in combination as esters and as free alcohols.[1] The amount of cholesterol or phytosterol is generally small, often inappreciable, and is indicated approximately by the unsaponifiable matter which it characterizes. Alcohols of the ethane and other series, free and in combination, compose a considerable proportion of waxes.

Oils and fats, therefore, may contain glycerides of monohydroxy and dihydroxy acids, possibly free hydroxy acids, monoglycerides and diglycerides and free alcohols; and the insoluble acids, separated from the oils and fats, may contain monohydroxy and dihydroxy acids and free alcohols. A portion, at least, of the free alcohols found in the insoluble acids probably occurred in the fat as esters. With the exclusion of the natural glycerides of hydroxy acids and a small amount of free alcohols, the acetyl number of many oils and fats may be deemed an index of quality, and when considered in conjunction with the acid and iodine numbers may serve to measure (more or less imperfectly, to be sure) the amount of hydrolysis and of oxidation the product has undergone. To differentiate between products of hydrolysis and of oxidation the acetyl number of the insoluble acids should also be determined.

Earlier Methods.

The several analytical processes that have been offered are based on the same chemical reactions, but differ in application and in details of procedure. The original method was devised by Benedikt and Ulzer[2] and applied to the insoluble acids. The acetyl number indicated the milligrams of potassium hydroxide required to neutralize the acetic acid obtained on saponifying one gram of acetylated insoluble fatty acids, and was determined by the difference between the acid and saponification numbers of the acetylated acids (acetyl ether number). The actual procedure consisted in saponifying the acetylated acids after neutralizing in alcohol. Lewkowitsch[3] has shown, however, that the results so obtained were generally in excess of the true values, due to the conversion of a part of the fatty acids on heating with a large excess of acetic anhydride into their anhydrides, as illustrated by the following equation: —

$$\underset{\text{fatty acid}}{2\,RCOOH} + \underset{\substack{\text{acetic}\\ \text{anhydride}}}{(CH_3CO)_2O} = \underset{\substack{\text{anhydride of}\\ \text{fatty acid}}}{(RCO)_2O} + \underset{\text{acetic acid}}{2\,CH_3COOH}$$

These fatty anhydrides are fairly stable compounds, but may become hydrolyzed to some extent on washing with boiling water. Subsequent treatment with cold alcohol in the determination of the acetyl acid

[1] See numerous references: Abderhalden, Physiological Chemistry (1908); Hammarsten, Physiological Chemistry (1911); Leathes, The Fats (1910).

[2] Monatsh. Chem., 8, pp. 41–48 (1887).

[3] Analysis of Oils, Fats and Waxes, 1, pp. 344, 345 (1909).

number will continue the hydrolysis, although a portion is likely to remain unchanged, thereby yielding too low an acid number, due to the inability of the anhydrides to combine with alkali. As complete hydrolysis occurs on saponification, the acetyl (ether) number would be too high and even appear when none exists.

Lewkowitsch[1] proposed the acetylation of the natural product. In conformity thereto the acetyl number indicates the milligrams of potassium hydroxide required for the neutralization of the acetic acid obtained on saponifying one gram of an acetylated oil, fat or wax. This method requires the saponification of the acetylated fat and the determination of the resulting acetic acid by either a filtration or distillation process. The former process is an adaptation of the regular method for the direct determination of soluble acids, and the latter process is a modified Reichert-Meissl test, with repeated distillation of the aqueous solution until the distillate is free from acids. The presence of natural soluble or volatile acids necessitates a similar treatment of the unacetylated fat in order to determine the amount of alkali assimilated by those acids for which proper corrections must be made to obtain the true acetyl number. The occurrence of the lower acids makes the determination a long and tedious operation.

Proposed Method.

Analytical methods for the examination of oils and fats is a subject that has been given considerable study by the writer in connection with feeding experiments and other investigations made at the Massachusetts Agricultural Experiment Station. During the past few years the determination of acetyl number has received particular attention with a view to evolving a process that might be free from the objections cited for the Benedikt and Ulzer, and Lewkowitsch methods. Believing that this end has been attained in some measure, a report of progress is now offered in the hope that it may lead to further improvement.

The custom of reporting acetyl number on the basis of the acetylated product appears unwarranted. It is contrary to general practice in analytical work and is the exception in fat analysis. The definition[2] here adopted places the acetyl number on a par with other tests, and is as follows: the acetyl number indicates the milligrams of potassium hydroxide required for the saponification of the acetyl assimilated by one gram of an oil, fat or wax on acetylation.

Method in Detail.

The development of the method extended over a period of several years, and finally resolved into an adaptation of several well-known processes. For instance, ceresine is used to solidify the acetylated fat so that it may be washed by decantation as in the determination of insoluble

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[1] *Loco citato*, 1, pp. 337, 338 (1909).

[2] The hydroxyl value of Twitchell is reported in a similar manner. Jour. Amer. Chem. Society, 29, pp. 566–571 (1907).

acids. The saponification number of the acetylated fat is determined by the same process as that of the original fat, and the difference measures the amount of acetyl that has been assimilated. The process may be appropriately described as a method by analogy.

The reagents employed in the determination are summarized so that their application may be clearly understood: —

Acetic anhydride, Kahlbaum's.

Ceresine, pure white, filtered.

Alcohol, redistilled, free from acids and aldehydes.

Alcoholic potash, 50 c.c. of a saturated solution of potassium hydroxide, free from carbonate, to 1,000 c.c. of alcohol. The solution should be allowed to stand at least twenty-four hours and filtered immediately before use.

$N/_2$ hydrochloric acid.

Alkali blue (6B), 1 gram to 100 c.c. of alcohol. The indicator should be digested in a stoppered bottle for several days at room temperature, with occasional shaking, and then filtered.

Phenolphthalein, 1 gram to 100 c.c. of alcohol, neutralized.

After what has been said, the details of the method should be so evident as to require no further explanation.

Into a 300 c.c. Erlenmeyer flask are brought 5 grams of fat, together with 10 c.c. of acetic anhydride. The flask is connected with a spiral or other form of reflux condenser and heated in a boiling water bath (immersed in the water) for from one to one and one-half hours. Longer heating yields higher results, but is accompanied by partial decomposition of the fat with formation of aldehydes or other bodies that give a reddish color with caustic alkali. . After acetylating, the flask is removed from the bath and sufficient ceresine added to form, with the fat, a solid disc when chilled in cold water. The amount of ceresine required will vary with the consistency of the product under examination. For butter fat .4 to .5 grams is ample; for softer fats and oils rather more; and for harder fats, less. The flask is heated on the water bath and the contents rotated until the ceresine and acetylated fat form a homogeneous mixture. One hundred and fifty c.c. of boiling water are then poured carefully into the flask with as little disturbance of the fat layer as possible, and the solution heated on the bath with occasional agitation to remove occluded acetic acid. The flask is immersed in cold water to solidify the ceresine-fat, after which the solution is decanted through a dense, ether-extracted filter, care being taken not to break the insoluble cake. Another 150 c.c. of boiling water are added, thoroughly agitated, heated as above, cooled and decanted, the process being repeated until the final filtrate gives a decided color with two or three drops of $N/_{10}$ alkali, using phenolphthalein as indicator (about six times). Prolonged washing is likely to cause slight dissociation of the acetylated product.

The filter and inverted flask containing the cake of ceresine-fat are allowed to drain in a cool place until practically dry. The small particles adhering to the filter are then scraped into the flask, and 50 c.c. of alcoholic potash, accurately measured with a burette, 50 c.c. of alcohol and several glass beads added. The flask is connected with a spiral or other form of reflux condenser and the solution boiled on a water bath until saponification is complete, — about sixty minutes. The flask is placed in a water bath at 60° C. and the solution, after cooling to that temperature, titrated with $N/_2$ hydrochloric acid, using 1 c.c. of alkali blue as indicator. Phenolphthalein may be employed, though less satisfactory for colored solutions. The alcoholic mixture is again brought to boil to free any alkali occluded in the ceresine, and retitered if necessary. Several blank determinations should be run with every series of tests under precisely similar conditions as to time and treatment, except that the ceresine may be omitted. However, every lot of ceresine must be tested, should be free from soluble matter and not assimilate any alkali on saponification. The difference between the titration of the blank and that of the excess alkali in the test is the acid equivalent of the fat after acetylation, which should be calculated to milligrams of potassium hydroxide for 1 gram of fat.

One c.c. of $N/_2$ acid is equivalent to 28.054 milligrams of potassium hydroxide.

The difference between the saponification number of the fat before and after acetylation is the acetyl number. In case the original fat contains *free soluble* acids, their titer should be determined and proper correction made for the same.

Limit of error, 0.50 acetyl number.

Synopsis of Reaction.

A better conception of the method may be obtained by a summary of the reactions: —

Acetylation of glycerides of monohydroxy and dihydroxy acids, monoglycerides and diglycerides and free alcohols. (See formulas.)
Saponification of the acetylated product. (See formulas.)
Saponification of the original or unacetylated product.
Titration of excess alkali.
Acetyl number by difference.

Glycerides of Monohydroxy and Dihydroxy Acids.

Acetylation: —

$$\underset{\text{triglyceride of monohydroxy acid}}{(R.OH.COO)_3C_3H_5} + \underset{\text{acetic anhydride}}{3(CH_3CO)_2O} = \underset{\text{acetylated glyceride}}{(R.OCH_3CO.COO)_3C_3H_5} + \underset{\text{acetic acid}}{3\,CH_3COOH}$$

Example: Ricinolein $(C_{17}H_{32}.OH.COO)_3C_3H_5$

Saponification: —

$$\underset{\text{acetylated glyceride}}{(R.OCH_3CO.COO)_3C_3H_5} + \underset{\text{alkali}}{6\,KOH}$$

$$= \underset{\text{potassium salt of hydroxy acid}}{3\,R.OH.COOK} + \underset{\text{potassium acetate}}{3\,CH_3COOK} + \underset{\text{glycerol}}{C_3H_5(OH)_3}$$

$$\underset{\text{triglyceride of dihydroxy acid}}{[R(OH)_2COO]_3C_3H_5} + (CH_3CO)_2O = \underset{\text{acetylated glyceride}}{[R(OCH_3CO)_2COO]_3C_3H_5} + H_2O$$

Example: Dihydroxystearin $[C_{17}H_{33}(OH)_2COO]_3C_3H_5$

$$[R(OCH_3CO)_2COO]_3C_3H_5 + 9\,KOH = 3\,R(OH)_2COOK + 6\,CH_3COOK + C_3H_5(OH)_3$$

Monoglycerides and Diglycerides.

$$\underset{\text{monoglyceride}}{(RCOO)C_3H_5(OH)_2} + (CH_3CO)_2O = \underset{\text{diaceto-glyceride}}{(RCOO)(CH_3COO)_2C_3H_5} + H_2O$$

$$(RCOO)(CH_3COO)_2C_3H_5 + 3\,KOH = RCOOK + 2\,CH_3COOK + C_3H_5(OH)_3$$

$$\underset{\text{diglyceride}}{(RCOO)_2C_3H_5(OH)} + (CH_3CO)_2O = \underset{\text{monaceto-glyceride}}{(RCOO)_2(CH_3COO)C_3H_5} + CH_3COOH$$

$$(RCOO)_2(CH_3COO)C_3H_5 + 3\,KOH = 2\,RCOOK + CH_3COOK + C_3H_5(OH)_3$$

Free Alcohols.

$$\underset{\text{monobasic alcohol}}{ROH} + (CH_3CO)_2O = \underset{\text{acetate of alcohol}}{CH_3COOR} + CH_3COOH$$

$$CH_3COOR + KOH = ROH + CH_3COOK$$

Examples: Cholesterol, phytosterol, $C_{27}H_{45}OH$

Considerable variation is possible in writing the above formulas which, at best, poorly express the structure. In some instances the reaction is indicated at some sacrifice of form.

Calculated Data from the Acetyl Number.

The acetyl number (c) serves to measure the amount of hydroxy compounds in an oil, fat or wax; and in case only one such compound of known molecular weight (m) and number of hydroxyls (d) is present, its amount (H) can be readily calculated by the following formula: —

$$H = \frac{cm}{56108\,d}$$

The derivation of the formula is comparatively simple. The theoretical acetyl number of a compound containing (d) hydroxyl groups is —

$$\frac{56108\,d}{m}$$

The amount of such a compound in an oil, fat or wax is, therefore —

$$\frac{c}{\frac{56108\,d}{m}} = \frac{cm}{56108\,d}$$

The same results may be calculated more easily from the following table, dividing the determined acetyl number by the theoretical acetyl number, or multiplying by its reciprocal: —

Acetyl Number on Original Product (Massachusetts Method).

Glycerides.

Name.	Formula.	Molecular Weight.	Saponification Number.	Theoretical Acetyl Number.	Reciprocal.
Ricinolein,	$(C_{17}H_{32}.OH.COO)_3C_3H_5$,	932 832	180.444	180.444	.0055419
Dihydroxystearin,	$[C_{17}H_{33}(OH)_2COO]_3C_3H_5$,	986.880	170.562	341.124	.0029315
Monoglycerides.					
Monopalmitin,	$(C_{15}H_{31}COO)C_3H_5(OH)_2$,	330.304	169.868	339.736	.0029435
Monostearin,	$(C_{17}H_{35}COO)C_3H_5(OH)_2$,	358.336	156.579	313.159	.0031933
Monolein,	$(C_{17}H_{33}COO)C_3H_5(OH)_2$,	356.320	157.465	314.930	.0031753

Acetyl Number on Original Product (Massachusetts Method) — Con.

Diglycerides.

NAME.	Formula.	Molecular Weight.	Saponification Number.	Theoretical Acetyl Number.	Reciprocal.
Dipalmitin, . .	$(C_{15}H_{31}COO)_2C_3H_5(OH)$, .	568.544	197.374	98.687	.0101330
Distearin, . .	$(C_{17}H_{35}COO)_2C_3H_5(OH)$, .	624.608	179.658	89.829	.0111323
Diolein, . . .	$(C_{17}H_{33}COO)_2C_3H_5(OH)$, .	620.576	180.826	90.413	.0110604

Hydroxy Acids.

NAME.	Formula.	Molecular Weight.	Saponification Number.	Theoretical Acetyl Number.	Reciprocal.
Ricinoleic, . .	$C_{17}H_{32}$. OH . COOH, . .	298.272	188.110	188.110	.0053160
Dihydroxystearic, .	$C_{17}H_{33}(OH)_2COOH$, . .	316.288	177.395	354.791	.0028186

Free Alcohols.

NAME.	Formula.	Molecular Weight.	Saponification Number.	Theoretical Acetyl Number.	Reciprocal.
Cholesterol, . .	$C_{27}H_{45}OH$, ...	386.368	–	145.219	.0068862
Phytosterol, . .	$C_{27}H_{45}OH$, ...	386.368	–	145.219	.0068862

GRAVIMETRIC PROCESS.[1]

After acetylating, a gravimetric process for acetyl number may be conducted in a manner similar to that for the quantitative determination of insoluble fatty acids, observing all the precautions therein noted as to ceresine, washing, drying, weighing, etc.

This modification is apparently rather more difficult, tedious and subject to error than the saponification or volumetric process (Massachusetts method). A certain amount of loss arises from the dehydration of free fatty acids by acetic anhydride during acetylation, and is difficult to prevent, although of little consequence where the amount of free acids is relatively small.

The acetyl number (a) is calculated from the increase in weight (i) by the following formula: —

$$a = \frac{56108\ i}{42.016} \text{ or } 1335.39604\ i$$

In case only one hydroxy compound of known molecular weight (m) and number of hydroxyls (d) is present, its amount can be calculated from the increase in weight (i) of the oil, fat or wax on acetylating. The theoretical increase for a hydroxy compound is —

$$\frac{42.016\ d}{m}$$

[1] This process has not received sufficient study in this laboratory to warrant positive statements, but is similar to the methods described by Lewkowitsch (*loco citato*), 1, pp. 358–363, 466, 467.

The amount (H) of such a compound in an oil, fat or wax is therefore —

$$H = \frac{i}{\frac{42.016\,d}{m}} \text{ or } \frac{im}{42.016\,d}$$

Molecular Weight of Hydroxy Compounds.

The molecular weight of the hydroxy compounds can be calculated from the weight (w) of fat taken and the increase (i) on acetylating, provided the number (d) of hydroxyls in the molecule is known: —

$$w : w + i = m : m + 42.016\,d$$

$$m = \frac{42.016\,dw}{i}$$

The formation of anhydrides during the acetylating process will affect the accuracy of these calculations.

The computation of the amount of hydroxy compounds by the gravimetric process is greatly facilitated by use of the following table: —

Acetyl Gravimetric Process on Original Product.

Glycerides.

Name.	Molecular Weight.	Molecular Weight after Acetylating.	Theoretical Increase in Weight per Gram on Acetylating.[1]	Reciprocal.
Ricinolein,	932.832	1058.880	.135124	7.40061
Dihydroxystearin,	986.880	1238.976	.255447	3.91471
Monoglycerides.				
Monopalmitin,	330.304	414.336	.254408	3.93069
Monostearin,	358.336	442.368	.234506	4.26428
Monolein,	356.320	440.352	.235833	4.24029
Diglycerides.				
Dipalmitin,	568.544	610.560	.073901	13.53162
Distearin,	624.608	666.624	.067268	14.86591
Diolein,	620.576	662.592	.067705	14.76996
Hydroxy Acids.				
Ricinoleic,	298.272	340.288	.140865	7.09900
Dihydroxystearic,	316.288	400.320	.265682	3.76390
Free Alcohols.				
Cholesterol,	386.368	428.384	.108746	9.19574
Phytosterol,	386.368	428.384	.108746	9.19574

[1] Acetyl number = 1335.39604 i.

Acetyl Number of Insoluble Fatty Acids.

The acetyl number of the insoluble fatty acids is determined by the Massachusetts method in precisely the same way as that of the original fat. The gravimetric process is not applicable on account of the formation of anhydrides of the fatty acids. The method for preparing the stock of insoluble acids for analysis is the same as that for the determination of "Insoluble Acids," with the elimination of such features as are necessary only for quantitative work.

In order to interpret the results satisfactorily it is necessary to know the percentage of insoluble acids so that the acetyl number of the acids may be considered in conjunction with the acetyl number of the fat.

Results by Different Methods.

For convenience, the theoretical acetyl numbers of some hydroxy compounds by the Benedikt and Ulzer, and Lewkowitsch methods are tabulated to permit comparison with the acetyl numbers by the Massachusetts and gravimetric processes previously stated. When only one hydroxy compound of known composition is present in an oil or fat the results can be readily converted from the basis of the original to that of the acetylated product and vice versa. In other cases conversion is generally impracticable on account of the marked differences in assimilation of acetyl by the several classes of hydroxy compounds. Formulas may show the relation, however, that the results by different methods bear to each other, (m) indicating the molecular weight of the hydroxy compound, (d) the number of hydroxyls, and (i) the increase in weight on acetylating: —

Massachusetts Method.

$$\frac{cm}{56108\ d}$$

Gravimetric Method.

$$\frac{im}{42.016\ d}$$

Benedikt and Ulzer, and Lewkowitsch Methods.

$$\frac{c(m + 42.016\ d)}{56108\ d}$$

Acetyl Number on Acetylated Product. (Benedikt and Ulzer, and Lewkowitsch Methods.)

Glycerides.

NAME (ACETYLATED).	Formula.	Molecular Weight.	Saponification Number.	Theoretical Acetyl Number.	Reciprocal.
Ricinolein, . .	$(C_{17}H_{32} . OCH_3CO . COO)_3C_3H_5$, .	1058.880	317.928	158.964	.0062907
Dihydroxystearin, .	$[C_{17}H_{33}(OCH_3CO)_2COO]_3C_3H_5$, .	1238.976	407.572	271.715	.0036803

Monoglycerides.

NAME (ACETYLATED).	Formula.	Molecular Weight.	Saponification Number.	Theoretical Acetyl Number.	Reciprocal.
Monopalmitin, .	$(C_{15}H_{31}COO) (CH_3COO)_2C_3H_5$, .	414.336	406.250	270.833	.0036923
Monostearin, .	$(C_{17}H_{35}COO) (CH_3COO)_2C_3H_5$, .	442.368	380.507	253.671	.0039421
Monolein, . .	$(C_{17}H_{33}COO) (CH_3COO)_2C_3H_5$, .	440.352	382.249	254.832	.0039242

Diglycerides.

NAME (ACETYLATED).	Formula.	Molecular Weight.	Saponification Number.	Theoretical Acetyl Number.	Reciprocal.
Dipalmitin, . .	$(C_{15}H_{31}COO)_2(CH_3COO)C_3H_5$, .	610.560	275.688	91.896	.0108819
Distearin, . .	$(C_{17}H_{35}COO)_2(CH_3COO)C_3H_5$, .	666.624	252.502	84.167	.0118811
Diolein, . . .	$(C_{17}H_{33}COO)_2(CH_3COO)C_3H_5$, .	662.592	254.039	84.680	.0118092

Hydroxy Acids.

NAME (ACETYLATED).	Formula.	Molecular Weight.	Saponification Number.	Theoretical Acetyl Number.	Reciprocal.
Ricinoleic, . .	$C_{17}H_{32}. OCH_3CO . COOH$, . .	340.288	329.768	164.884	.0060649
Dihydroxystearic, .	$C_{17}H_{33} (OCH_3CO)_2COOH$, . .	400.320	420.474	280.316	.0035674

Free Alcohols.

NAME (ACETYLATED).	Formula.	Molecular Weight.	Saponification Number.	Theoretical Acetyl Number.	Reciprocal.
Cholesterol, . .	$CH_3COO\ C_{27}H_{45}$, ...	428.384	–	130.976	.0076350
Phytosterol, . .	$CH_3COO\ C_{27}H_{45}$, ...	428.384	–	130.976	.0076350

RÉSUMÉ.

The acetyl numbers of a fat and of the insoluble acids afford valuable information relative to the nature and the quality of a product. Apparently many analysts have been deterred from making the determinations on account of the time required, tedious manipulation involved or inability to interpret the results. The proposed method is comparatively short and simple and readily understood because of its similarity to other fat methods in common use. It is practically free from the objections cited for the earlier methods, and the results are directly comparable with other fat determinations, being on the same basis.

THE DIGESTIBILITY OF CATTLE FOODS.

BY J. B. LINDSEY AND P. H. SMITH.

Foreword.

The digestion experiments herein reported were made during the autumn, winter and early spring of 1910–11, 1911–12, 1912–13 and also, two experiments, in the autumn of 1913. They form part of what are known as Series XVI., XVII., XVIII. and XIX. The experiments made in these series and not here included have either been published in previous reports or will be found in later publications.

The usual method was employed and has been fully described elsewhere.[1] The full data are here presented, with the exception of the daily production of manure and the daily water consumption, in which cases, to economize space, averages only are given. The periods extended over fourteen days, the first seven of which were preliminary, collection of feces being made during the last seven. Ten grams of salt were given each sheep daily with water *ad libitum*. The sheep used in these experiments were grade Shropshires of substantially uniform weight, born in 1907.

1. Series XVI.

The hay used in connection with this series consisted of fine mixed grasses, and contained a large proportion of June grass (*Poa pratensis*). The digestion coefficients of this hay, as obtained in Period I., were applied to the two experiments on beet pulp which follow: —

[1] Eleventh report of the Mass. State Agr. Exp. Sta., pp. 146–149; also the 22d report of the Mass. Agr. Exp. Sta., p. 84.

Composition of Feedstuffs (Per Cent).

[Dry Matter.]

Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
English hay, Period I.,	7.47	9.58	30.98	49.36	2.61
English hay, Period II.,	6.96	9.90	31.39	49.13	2.62
English hay, Period III.,	6.66	9.64	30.76	50.46	2.48
Waste, Sheep I., Period I.,	8.89	5.86	36.92	46.94	1.39
Molasses dried beet pulp,	5.56	11.68	16.40	65.89	.47
Plain dried beet pulp,	3.29	8.12	20.46	67.76	.37

Composition of Feces (Per Cent).

[Dry Matter.]

Sheep I.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay,	13.61	11.82	25.82	45.49	3.26
II.	Molasses dried beet pulp,	13.15	15.27	24.46	43.03	4.09
III.	Dried beet pulp,	12.20	13.49	25.81	44.63	3.87
	Sheep II.					
I.	English hay,	13.37	11.13	28.27	44.32	2.91
II.	Molasses dried beet pulp,	13.67	15.69	25.10	41.87	3.67
III.	Dried beet pulp,	11.98	12.37	27.55	44.25	3.85

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent).

Sheep I.

Period.	English Hay.	Molasses Dried Beet Pulp.	Dried Beet Pulp.	Waste.	Feces.
I.,	88.55	-	-	83.40	93.62
II.,	89.85	89.60	-	-	92.25
III.,	90.90	-	89.64	-	88.83
Sheep II.					
I.,	88.55	-	-	-	93.57
II.,	89.85	89.60	-	-	92.47
III.,	90.90	-	89.64	-	89.02

Average Daily Amount of Manure excreted and Water drunk (Grams).

Sheep I.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	English hay,	627	27.600	1,512
II.	Molasses dried beet pulp,	684	23.470	1,893
III.	Dried beet pulp,	695	26.097	1,829

Sheep II.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	English hay,	1,032	30.768	2,465
II.	Molasses dried beet pulp,	983	24.881	2,611
III.	Dried beet pulp,	605	27.486	1,946

Weights of Animals for Two Days at Beginning and Two Days at the End of Period (Pounds).

Sheep I.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	English hay,	122.00	121.75	120.00	119.00
II.	Molasses dried beet pulp,	128.25	126.50	125.25	126.25
III.	Dried beet pulp,	126.25	127.00	125.25	125.00

Sheep II.

Period.	Character of Food or Ration.	First Weight.	Second Weight.	First Weight.	Second Weight.
I.	English hay,	125.00	128.50	126.50	126.50
II.	Molasses dried beet pulp,	142.25	141.50	140.25	140.00
III.	Dried beet pulp,	140.75	139.75	138.50	138.50

English Hay, Period I.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed daily,	708.40	52.92	67.86	219.46	349.67	18.49
13.75 grams waste,	11.47	1.02	.67	4.23	5.39	.16
Amount consumed,	696.93	51.90	67.19	215.23	344.28	18.33
276.03 grams manure excreted,	258.42	35.17	30.55	66.72	117.56	8.42
Grams digested,	438.51	16.73	36.64	148.51	226.72	9.91
Per cent. digested,	62.92	32.24	54.53	69.00	65.85	54.06

English Hay, Period I — Concluded.

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed daily, .	708.40	52.92	67.86	219.46	349.67	18.49
307.68 grams manure excreted, . .	287.90	38.49	32.04	81.39	127.60	8.38
Grams digested, ...	420.50	14.43	35.82	138.07	222.07	10.11
Per cent. digested, ...	59.36	27.27	52.79	62.91	63.51	54.68
Average per cent. for both sheep, .	61.14	29.76	53.66	65.96	64.68	54.37

Average nutritive ratio of rations for both sheep, 1:10.7.

Molasses Dried Beet Pulp, Period II.

Sheep I.

500 grams English hay fed, . .	449.25	31.27	44.48	141.02	220.71	11.77
300 grams molasses dried beet pulp fed,	268.80	14.94	31.40	44.08	177.12	1.26
Amount consumed, ...	718.05	46.21	75.88	185.10	397.83	13.03
234.70 grams manure excreted, . .	216.51	28.47	33.06	52.96	93.16	8.86
Grams digested, ...	501.54	17.74	42.82	132.14	304.67	4.17
Minus hay digested, ...	274.04	9.38	24.02	93.07	143.46	6.36
Molasses dried beet pulp digested, .	227.50	8.36	18.80	39.07	161.21	-
Per cent. digested, ...	84.64	55.96	59.87	88.63	91.02	-

Sheep II.

Amount consumed as above, . .	718.05	46.21	75.88	185.10	397.83	13.03
248.81 grams manure excreted, . .	230.07	31.45	36.10	57.75	96.33	8.44
Grams digested, ...	487.98	14.76	39.78	127.35	301.50	4.59
Minus hay digested, ...	274.04	9.38	24.02	93.07	143.46	6.36
Molasses dried beet pulp digested, .	213.94	5.38	15.76	34.28	158.04	-
Per cent. digested, ...	79.57	36.01	50.19	77.77	89.23	-
Average per cent. for both sheep, .	82.11	45.99	55.03	83.20	90.13	-

Average nutritive ratio of rations for both sheep, 1:10.7.

Dried Beet Pulp, Period III.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	499.95	33.30	48.20	153.78	252.27	12.40
250 grams dried beet pulp fed,	224.10	7.37	18.19	45.86	151.85	.83
Amount consumed,	724.05	40.67	66.39	199.64	404.12	13.23
260.97 grams manure excreted,	231.82	28.28	31.27	59.83	103.47	8.97
Grams digested,	492.23	12.39	35.12	139.81	300.65	4.26
Minus hay digested,	304.97	9.99	26.03	101.49	163.98	6.70
Dried beet pulp digested,	187.26	2.40	9.09	38.32	136.67	-
Per cent. digested,	76.72	32.56	49.97	83.56	90.00	-

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	724.05	40.67	66.39	199.64	404.12	13.23
274.86 grams manure excreted,	244.68	29.31	30.27	67.41	108.27	9.42
Grams digested,	479.37	11.36	36.12	132.23	295.85	3.81
Minus hay digested,	304.97	9.99	26.03	101.49	163.98	6.70
Dried beet pulp digested,	174.40	1.37	10.09	30.74	131.87	-
Per cent. digested,	71.45	18.59	55.47	67.03	86.84	-
Average per cent. for both sheep,	74.09	25.58	52.72	75.30	88.42	-

Average nutritive ratio of rations for both sheep, 1:12.4.

2. Series XVII.

Digestion Coefficients of Basal Ration used in this Series.

[English Hay.]

	Periods I.-VII.	Periods VIII.-X.
Dry matter,	62	65
Ash,	34	46
Protein,	55	65
Fiber,	68	67
Nitrogen-free extract,	65	67
Fat,	48	46

Composition of Feedstuffs (Per Cent).

[Dry Matter.]

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay, ...	7.75	9.06	31.65	49.16	2.38
II.	English hay, ...	7.51	9.44	31.73	48.96	2.36
II.	Cocoanut meal, ...	6.97	21.17	9.23	52.58	10.05
III.	English hay, ...	8.19	10.36	30.46	48.37	2.62
III.	Cottonseed feed meal, Creamo brand,	5.28	23.75	21.22	44.32	5.43
IV.	English hay, ...	7.65	10.02	32.48	47.58	2.27
IV.	Wheat screenings, ...	5.19	17.20	10.52	60.05	7.04
V.	English hay, ...	6.92	10.17	30.65	49.92	2.34
V.	Molasses dried beet pulp, . . .	5.69	11.44	15.88	66.72	.27
V.	Dried beet pulp, ...	3.16	8.01	27.22	61.38	.23
VI.	English hay, ...	6.26	9.50	32.52	49.18	2.54
VI.	Flax shives, ...	5.59	16.54	35.90	38.75	3.22
VII.	English hay, ...	7.13	9.85	30.91	49.66	2.45
VII.	Cocoanut meal, ...	6.06	21.58	9.83	52.42	10.11
VIII.	English hay, ...	6.73	10.37	30.18	49.84	2.88
IX.	English hay, ...	5.70	9.90	30.50	51.03	2.87
IX.	Cocoa shells, ...	8.83	14.55	13.25	58.23	5.14
X.	English hay, ...	5.46	9.40	31.35	50.77	3.02
X.	Wheat screenings, ...	4.28	17.50	8.29	64.66	5 27

Composition of Feces (Per Cent).

[Dry Matter.]

Sheep I.

IX.	Cocoa shells, ...	10.88	15.09	26.20	44.45	3.38

Sheep II.

IX.	Cocoa shells, ...	10.94	14.13	25.14	46.38	3.41

Sheep III.

V.	Dried beet pulp, ...	12.31	13.00	20.13	50.50	4.06

Sheep IV.

IV.	Molasses dried beet pulp, . . .	12.17	13.00	27.00	43.82	4.01

Composition of Feces (Per Cent.) — Concluded.

Sheep V.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay,	13.65	10.80	27.32	45.04	3.19
III.	Cottonseed feed meal, Creamo brand,	12.25	13.11	28.23	43.89	2.52
IV.	Wheat screenings,	12.07	10.95	28.21	45.89	2.88
VI.	Flax shives,	9.66	9.20	35.55	43.26	2.33
VII.	Cocoanut meal,	12.12	11.51	28.81	44.74	2.82
VIII.	English hay,	9.87	10.30	28.36	47.35	4.12
X.	Wheat screenings,	10.48	11.74	28.47	45.35	3.96
	Sheep VI.					
I.	English hay,	13.50	10.68	26.56	45.88	3.38
II.	Cocoanut meal,	13.24	11.93	27.40	44.57	2.86
III.	Cottonseed feed meal, Creamo brand,	11.93	12.50	29.55	43.37	2.65
IV.	Wheat screenings,	12.36	10.79	27.77	46.20	2.88
VI.	Flax shives,	9.91	9.27	34.88	43.55	2.39
VII.	Cocoanut meal,	12.48	11.22	28.80	44.71	2.79
VIII.	English hay,	10.88	10.53	27.61	46.21	4.47
X.	Wheat screenings,	11.22	11.96	28.54	44.40	3.88

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.).

Sheep I.

Period.	English Hay.	Molasses Dried Beet Pulp.	Dried Beet Pulp.	Cocoa Shells.	Feces.
IX.,	89.20	-	-	95.47	92.18
Sheep II.					
IX.,	89.20	-	-	95.47	92.38
Sheep III.					
V.,	92.97	-	90.92	-	94.91
Sheep IV.					
V.,	92.97	94.04	-	-	94.85

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.) — Concluded.

Sheep V.

Period.	English Hay.	Cocoanut Meal.	Cotton-seed Feed Meal.	Wheat Screenings.	Flax Shives.	Feces.
I.,	88.50	-	-	-	-	93.30
III.,	87.57	-	89.70	-	-	93.77
IV.,	89.45	-	-	91.94	-	95.41
VI.,	93.25	-	-	-	90.02	95.16
VII.,	90.70	92.86	-	-	-	93.68
VIII.,	90.67	-	-	-	-	92.94
X.,	89.47	-	-	88.52	-	93.11

Sheep VI.

Period.	English Hay.	Cocoanut Meal.	Cotton-seed Feed Meal.	Wheat Screenings.	Flax Shives.	Feces.
I.,	88.50	-	-	-	-	93.25
II.,	87.82	88.37	-	-	-	93.52
III.,	87.57	-	89.70	-	-	94.06
IV.,	89.45	-	-	91.94	-	95.44
VI.,	93.25	-	-	-	90.02	95.18
VII.,	90.70	92.86	-	-	-	93.75
VIII.,	90.67	-	-	-	-	93.03
X.,	89.47	-	-	88.52	-	93.32

Average Daily Amount of Manure excreted and Water drunk (Grams).

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
	Sheep I.			
IX.	Cocoa shells,	898	28.76	2,168
	Sheep II.			
IX.	Cocoa shells,	661	28.40	2,510
	Sheep III.			
V.	Dried beet pulp,	590	26.33	1,975
	Sheep IV.			
V.	Molasses dried beet pulp,	708	24.75	2,482

Average Daily Amount of Manure excreted and Water drunk (Grams) — Concluded.

Sheep V.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	English hay, ...	559	29.30	971
III.	Cottonseed feed meal, Creamo brand, . .	554	29.08	1,493
IV.	Wheat screenings, ...	586	29.55	951
VI.	Flax shives, ...	752	35.84	1,691
VII.	Cocoanut meal, ...	580	27.13	1,839
VIII.	English hay, ...	583	27.93	1,902
X.	Wheat screenings, ...	739	26.85	2,202

Sheep VI.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	English hay, ...	554	28.07	1,474
II.	Cocoanut meal, ...	498	25.50	1,403
III.	Cottonseed feed meal, Creamo brand, . .	570	29.40	2,011
IV.	Wheat screenings, ...	583	28.95	2,165
VI.	Flax shives, ...	685	34.67	2,806
VII.	Cocoanut meal, ...	556	26.31	3,141
VIII.	English hay, ...	536	26.97	3,289
X.	Wheat screenings, ...	662	26.09	3,494

Weights of Animals for Two Days at Beginning and Two Days at the End of Period (Pounds).

Sheep I.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
IX.	Cocoa shells, ...	146.50	144.00	142.50	142.50

Sheep II.

Period.	Character of Food or Ration.	Beginning. First Weight.	Beginning. Second Weight.	End. First Weight.	End. Second Weight.
IX.	Cocoa shells, ...	143.50	142.50	143.00	143.00

Sheep III.

Period.	Character of Food or Ration.	Beginning. First Weight.	Beginning. Second Weight.	End. First Weight.	End. Second Weight.
V.	Dried beet pulp, ...	160.00	158.75	162.00	160.50

Weights of Animals for Two Days at Beginning and Two Days at the End of Period (Pounds) — Concluded.

Sheep IV.

Period.	Character of Food or Ration.	Beginning. First Weight.	Beginning. Second Weight.	End. First Weight.	End. Second Weight.
V.	Molasses dried beet pulp,	164.50	163.00	163.00	162.50

Sheep V.

Period.	Character of Food or Ration.	Beginning. First Weight.	Beginning. Second Weight.	End. First Weight.	End. Second Weight.
I.	English hay,	163.25	163.25	159.25	160.75
III.	Cottonseed feed meal, Creamo brand,	158.25	159.25	158.25	156.50
IV.	Wheat screenings,	158.75	158.00	159.50	157.00
VI.	Flax shives,	168.50	167.50	164.75	164.75
VII.	Cocoanut meal,	167.50	169.75	165.50	163.00
				163.25	166.25
VIII.	English hay,	163.50	161.50	162.50	161.50
X.	Wheat screenings,	162.00	161.50	158.50	157.50

Sheep VI.

Period.	Character of Food or Ration.	Beginning. First Weight.	Beginning. Second Weight.	End. First Weight.	End. Second Weight.
I.	English hay,	146.75	146.75	146.75	147.00
II.	Cocoanut meal,	146.75	145.00	143.50	145.50
III.	Cottonseed feed meal, Creamo brand,	141.50	142.00	141.00	139.25
IV.	Wheat screenings,	143.00	142.00	141.25	139.50
VI.	Flax shives,	156.50	157.00	154.25	154.50
VII.	Cocoanut meal,	151.50	151.50	153.50	152.00
				152.50	150.00
VIII.	English hay,	151.00	151.75	152.00	150.50
X.	Wheat screenings,	150.00	149.50	148.00	148.25

English Hay, Period I.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	708.00	54.87	64.14	224.08	348.06	16.85
293 grams manure excreted,	273.37	37.32	29.52	74.68	123.13	8.72
Grams digested,	434.63	17.55	34.62	149.40	224.93	8.13
Per cent. digested,	61.39	31.98	53.98	66.67	64.62	48.25

English Hay, Period I — Concluded.

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	708.00	54.87	64.14	224.08	348.06	16.85
280.67 grams manure excreted,	261.72	35.33	27.95	69.51	120.08	8.85
Grams digested,	446.28	19.54	36.19	154.57	227.98	8.00
Per cent. digested,	63.03	35.61	56.42	68.98	65.50	47.48
Average per cent. for both sheep,	62.21	33.80	55.20	67.83	65.06	47.87

Average nutritive ratio of rations for both sheep, 1:11.2.

Cocoanut Meal, Period II.

Sheep VI.

650 grams English hay fed,	570.83	42.87	53.87	181.13	279.49	13.47
150 grams cocoanut meal fed,	132.56	9.24	28.06	12.24	69.70	13.32
Amount consumed,	703.39	52.11	81.93	193.37	349.19	26.79
255 grams manure excreted,	238.48	31.57	28.45	65.34	106.30	6.82
Grams digested,	464.91	20.54	53.48	128.03	242.89	19.97
Minus hay digested,	353.91	14.58	29.63	123.17	181.67	6.47
Cocoanut meal digested,	111.00	5.96	23.85	4.86	61.22	13.50
Per cent. digested,	83.74	64.50	85.00	39.71	87.83	101.35

Average nutritive ratio of ration, 1:7.8.

Cottonseed Feed Meal, Creamo Brand, Period III.

Sheep V.

600 grams English hay fed,	525.42	43.03	54.43	160.04	254.15	13.77
200 grams cottonseed feed meal fed,	179.40	9.47	42.61	38.07	79.51	9.74
Amount consumed,	704.82	52.50	97.04	198.11	333.66	23.51
290.8 grams manure excreted,	272.68	33.40	35.45	76.98	119.68	6.87
Grams digested,	432.14	19.10	61.59	121.13	213.98	16.64
Minus hay digested,	325.76	14.63	29.94	108.83	165.20	6.61
Cottonseed feed meal digested,	106.38	4.47	31.65	12.30	48.78	10.03
Per cent. digested,	59.30	47.20	74.28	32.31	61.35	102.97

Cottonseed Feed Meal, Creamo Brand, Period III — Concluded.

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	704.82	52.50	97.04	198.11	333.66	23.51
293.99 grams manure excreted,	276.53	32.99	34.57	81.71	119.93	7.33
Grams digested,	428.29	19.51	62.47	116.40	213.73	16.18
Minus hay digested,	325.76	14.63	29.94	108.83	165.20	6.61
Cottonseed feed meal digested,	102.53	4.88	32.53	7.57	48.53	9.57
Per cent. digested,	57.15	51.53	76.34	19.88	61.04	98.25
Average per cent. for both sheep,	58.23	49.37	75.31	26.10	61.20	100.61

Average nutritive ratio of rations for both sheep, 1:5.94.

Wheat Screenings, Period IV.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed,	536.70	41.06	53.78	174.32	255.36	12.18
200 grams wheat screenings fed,	183.88	9.54	31.63	19.34	110.42	12.95
Amount consumed,	720.58	50.60	85.41	193.66	365.78	25.13
295.54 grams manure excreted,	281.97	34.03	30.88	79.54	129.40	8.12
Grams digested,	438.61	16.57	54.53	114.12	236.38	17.01
Minus hay digested,	332.75	13.96	29.58	118.54	165.98	5.85
Wheat screenings digested,	105.86	2.61	24.95	–	70.40	11.16
Per cent. digested,	57.57	27.36	78.88	–	63.76	86.18

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	720.58	50.60	85.41	193.66	365.78	25.13
289.51 grams manure excreted,	276.31	34.15	29.81	76.73	127.66	7.96
Grams digested,	444.27	16.45	55.60	116.93	238.12	17.17
Minus hay digested,	332.75	13.96	29.58	118.54	165.98	5.85
Wheat screenings digested,	111.52	2.49	26.02	–	72.14	11.32
Per cent. digested,	60.65	26.19	82.97	–	65.33	87.41
Average per cent. for both sheep,	59.11	26.73	80.93	–	64.55	86.80

Average nutritive ratio of rations for both sheep, 1:7.1.

Dried Beet Pulp, Period V.

Sheep III.

—	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed, . . .	511.34	35.39	52.00	156.73	255.25	11.97
250 grams dried beet pulp fed, . .	227.30	7.18	18.21	61.87	139.52	.52
Amount consumed, ...	738.64	42.57	70.21	218.60	394.77	12.49
263.27 grams manure excreted, . .	249.87	30.76	32.48	50.30	126.19	10.14
Grams digested, ...	488.77	11.81	37.73	168.30	268.58	2.35
Minus hay digested, ...	317.03	12.03	28.60	106.58	165.91	5.75
Dried beet pulp digested, . . .	171.74	–	9.13	61.72	102.67	–
Per cent. digested, ...	75.56	–	50.14	99.76	73.59	–

Average nutritive ratio of ration, 1:11.7.

Molasses Dried Beet Pulp, Period V.

Sheep IV.

550 grams English hay fed, . .	511.34	35.39	52.00	156.73	255.25	11.97
250 grams molasses dried beet pulp fed,	235.10	13.38	26.90	37.33	156.86	.63
Amount consumed, ...	746.44	48.77	78.90	194.06	412.11	12.60
247.50 grams manure excreted, . .	234.75	28.57	30.52	63.38	102.87	9.41
Grams digested, ...	511.69	20.20	48.38	130.68	309.24	3.19
Minus hay digested, ...	317.03	12.03	28.60	106.58	165.91	5.75
Molasses dried beet pulp digested, .	194.66	8.17	19.78	24.10	143.33	–
Per cent. digested, ...	82.80	61.06	73.53	64.56	91.37	–

Average nutritive ratio of ration, 1:9.2.

Flax Shives, Period VI.

Sheep V.

600 grams English hay fed, . .	559.50	35.02	53.15	181.95	275.17	14.21
250 grams flax shives fed, . . .	225.05	12.58	37.22	80.79	87.21	7.25
Amount consumed, ...	784.55	47.60	90.37	262.74	362.38	21.46
358.38 grams manure excreted, . .	341.03	32.94	31.37	121.24	147.53	7.95
Grams digested, ...	443.52	14.66	59.00	141.50	214.85	13.51
Minus hay digested, ...	346.89	11.91	29.23	123.73	178.86	6.82
Flax shives digested, ...	96.63	2.75	29.77	17.77	35.99	6.69
Per cent. digested, ...	42.94	21.86	79.98	22.00	41.27	92.26

Flax Shives, Period VI — Concluded.

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . .	784.55	47.60	90.37	262.74	362.38	21.46
346.74 grams manure excreted, . .	330.03	32.71	30.59	115.11	143.73	7.89
Grams digested, ...	454.52	14.89	59.78	147.63	218.65	13.57
Minus hay digested, ...	346.89	11.91	29.23	123.73	178.86	6.82
Flax shives digested, ...	107.63	2.98	30.55	23.90	39.79	6.75
Per cent. digested, ...	47.82	23.69	82.08	29.58	45.63	93.09
Average per cent. for both sheep, .	45.38	22.78	81.03	25.79	43.45	92.68

Average nutritive ratio of rations for both sheep, 1:6.6.

Cocoanut Meal, Period VII.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams English hay fed, . .	589.55	42.03	58.07	182.23	292.78	14.44
150 grams cocoanut meal fed, . .	139.29	8.44	30.06	13.69	73.02	14.08
Amount consumed, ...	728.84	50.47	88.13	195.92	365.80	28.52
271.34 grams manure excreted, . .	254.19	30.81	29.26	73.23	113.72	7.17
Grams digested, ...	474.65	19.66	58.87	122.69	252.08	21.35
Minus hay digested, ...	365.52	14.29	31.94	123.92	190.31	6.93
Cocoanut meal digested, . . .	109.13	5.37	26.93	-	61.77	14.42
Per cent. digested, ...	78.34	63.63	89.59	-	84.59	102.41

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . .	728.84	50.47	88.13	195.92	365.80	28.52
263.11 grams manure excreted, . .	246.67	30.78	27.68	71.04	110.29	6.88
Grams digested, ...	482 17	19.69	60.45	124.88	255.51	21.64
Minus hay digested, ...	365.52	14.29	31.94	123.92	190.31	6.93
Cocoanut meal digested, . . .	116.65	5.40	28.51	.96	65.20	14.71
Per cent. digested, ...	83.74	63.98	94.84	7.01	89.29	104.47
Average per cent. for both sheep, .	81.04	63.81	92 22	-	86.94	103.44

Average nutritive ratio of rations for both sheep, 1:7.1.

English Hay, Period VIII.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	725.36	48.82	75.22	218.91	361.52	20.89
279.28 grams manure excreted,	259.56	25.62	26.73	73.61	122.91	10.69
Grams digested,	465.80	23.20	48.49	145.30	238.61	10.20
Per cent. digested,	64.22	47.52	64.46	66.37	66.00	48.83

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	725.36	48.82	75.22	218.91	361.52	20.89
269.70 grams manure excreted,	250.90	27.30	26.42	69.27	115.94	11.97
Grams digested,	474.46	21.52	48.80	149.64	245.58	8.92
Per cent. digested,	65.41	44.08	64.88	68.36	67.93	42.70
Average per cent. for both sheep,	64.82	45.80	64.67	67.37	66.97	45.77

Average nutritive ratio of rations for both sheep, 1:8.4.

Cocoa Shells, Period IX.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams English hay fed,	579.80	33.05	57.40	176.83	295.88	16.64
150 grams cocoa shells fed,	143.21	12.65	20.84	18.98	83.38	7.36
Amount consumed,	723.01	45.70	78.24	195.81	379.26	24.00
287.64 grams manure excreted,	265.15	28.85	40.01	69.47	117.86	8.96
Grams digested,	457.86	16.85	38.23	126.34	261.40	15.04
Minus hay digested,	376.87	15.20	37.31	118.48	198.24	7.65
Cocoa shells digested,	80.99	1.65	.92	7.86	63.16	7.39
Per cent. digested,	56.55	13.04	4.41	41.41	75.75	100.41

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	723.01	45.70	78.24	195.81	379.26	24.00
284.01 grams manure excreted,	262.37	28.70	37.07	65.96	121.69	8.95
Grams digested,	460.64	17.00	41.17	129.85	257.57	15.05
Minus hay digested,	376.87	15.20	37.31	118.48	198.24	7.65
Cocoa shells digested,	83.77	1.80	3.86	11.37	59.33	7.40
Per cent. digested,	58.49	14.23	18.52	59.91	71.16	100.54
Average per cent. for both sheep,	57.52	13.64	11.47	50.66	73.46	100.48

Average nutritive ratio of rations for both sheep, 1:10.6.

Wheat Screenings, Period X.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed,	536.82	29.31	50.46	168.29	272.55	16.21
200 grams wheat screenings fed,	177.04	7.58	30.98	14.68	114.47	9.33
Amount consumed,	713.86	36.89	81.44	182.97	387.02	25.54
268.48 grams manure excreted,	249.98	26.20	29.35	71.17	113.36	9.90
Grams digested,	463.88	10.69	52.09	111.80	273.66	15.64
Minus hay digested,	348.93	13.48	32.80	112.75	182.61	7.46
Wheat screenings digested,	114.95	-	19.29	-	91.05	8.18
Per cent. digested,	64.93	-	62.26	-	79.54	87.67

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	713.86	36.89	81.44	182.97	387.02	25.54
260.94 grams manure excreted,	243.51	27.32	29.12	69.50	108.12	9.45
Grams digested,	470.35	9.57	52.32	113.47	278.90	16.09
Minus hay digested,	348.93	13.48	32.80	112.75	182.61	7.46
Wheat screenings digested,	121.42	-	19.52	-	96.29	8.63
Per cent. digested,	68.58	-	63.01	-	84.12	92.50
Average per cent. for both sheep,	66.76	-	62.64	-	81.83	90.09

Average nutritive ratio of rations for both sheep, 1:8.1.

3. Series XVIII.

Digestion Coefficients of Basal Ration used in this Series.

	English Hay. Sheep I. and II.	English Hay. Sheep V. and VI.	English Hay and Corn Meal. Periods X. and XII. Sheep I. and II.
Dry matter,	65	65	70
Ash,	31	46	43
Protein,	61	65	63
Fiber,	70	67	71
Nitrogen-free extract,	67	67	74
Fat,	53	46	59

Composition of Feedstuffs (Per Cent).

[Dry Matter.]

Period.	Feedstuffs.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay,	4.90	9.75	31.46	50.95	2.94
II.	English hay,	5.78	9.56	31.48	50.45	2.73
II.	Corn meal,	1.39	10.74	2.77	80.07	5.03
VIII.	Brook Farm hay,	6.46	8.27	33.89	49.31	2.07
VIII.	Waste Sheep I.,	4.68	4.56	38.09	51.61	1.06
VIII.	Waste Sheep II.,	6.09	7.28	33.46	51.48	1.69
IX.	English hay,	6.53	9.35	32.10	49.13	2.89
IX.	CXX Feed, Postum Cereal refuse.	2.74	19.57	18.11	56.46	3.12
X.	English hay,	6.41	9.80	31.84	49.31	2.64
X.	Corn meal,	1.46	10.93	2.60	80.15	4.86
X.	Gloucester fish meal,	24.01	73.17	–	–	2.82
XI.	English hay,	6.72	9.72	31.65	49.32	2.59
XI.	Molassine meal,	9.40	10.81	7.54	71.72	.53
XII.	English hay,	6.49	9.62	31.64	49.51	2.74
XII.	Corn meal,	1.50	10.78	2.72	80.15	4.85
XII.	Wilcox fish guano,	16.90	55.46	–	–	7.72
XIII.	English hay,	6.40	8.80	32.45	49.53	2.82
XIII.	Mellen's Food refuse,	4.38	13.51	18.24	59.64	4.23
XIV.	English hay,	6.47	8.90	31.89	49.95	2.79
XIV.	Molassine meal,	9.47	12.49	7.79	69.65	.60
XIV.	Waste Sheep I.,	13.60	11.33	16.54	57.08	1.45
XIV.	Brook Farm hay,	6.32	8.90	32.12	50.53	2.13

Composition of Feces (Per Cent).

[Dry Matter.]

Sheep I.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay,	9.73	11.37	26.53	48.35	4.02
II.	Corn meal,	9.33	12.47	25.89	48.16	4.15
VIII.	Brook Farm hay,	9.04	11.62	26.31	49.73	3.30
X.	Gloucester fish meal,	15.30	17.46	21.67	42.17	3.40
XII.	Wilcox fish guano,	14.34	14.74	23.29	44.29	3.34
XIV.	Molassine meal,	11.48	13.22	24.80	47.32	3.18

Composition of Feces (Per Cent.) — Concluded.

[Dry Matter.]

Sheep II.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay, ...	9.83	10.60	27.48	48.08	4.01
II.	Corn meal, ...	10.12	11.68	26.73	47.08	4.39
VIII.	Brook Farm hay, . . .	8.57	9.87	28.59	49.88	3.09
X.	Gloucester fish meal, . . .	16.92	18.35	20.29	40.71	3.73
XII.	Wilcox fish guano, . . .	15.36	16.41	21.36	43.30	3.57

Sheep V.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
IX.	CXX Feed, Postum Cereal refuse.	8.38	17.47	28.78	42.22	3.15
XI.	Molassine meal, ...	8.76	12.64	26.74	48.06	3.80
XIII.	Mellen's Food refuse, . . .	10.32	10.99	27.60	47.81	3.28
XIV.	Brook Farm hay, . . .	9.64	10.21	30.07	47.02	3.06

Sheep VI.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
IX.	CXX Feed, Postum Cereal refuse.	8.36	16.76	29.35	42.54	2.99
XI.	Molassine meal, ...	9.03	12.54	26.70	48.13	3.60
XIII.	Mellen's Food refuse, . . .	10.54	11.69	25.81	48.84	3.12

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.).

Sheep I.

Period.	English Hay.	Corn Meal.	Brook Farm Hay.	Gloucester Fish Meal.	Wilcox Fish Guano.	Molassine Meal.	CXX Feed.	Mellen's Food Refuse.	Waste.	Feces.
I.	88.62	-	-	-	-	-	-	-	-	92.50
II.	88.32	86.55	-	-	-	-	-	-	-	93.02
VIII.	-	-	88.97	-	-	-	-	-	90.12	95.52
X.	90.75	88.36	-	94.28	-	-	-	-	-	93.52
XII.	89.25	87.57	-	-	91.62	-	-	-	-	93.09
XIV.	89.60	-	-	-	-	80.81	-	-	74.76	92.20

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.) — Concluded.

Sheep II.

Period.	English Hay.	Corn Meal.	Brook Farm Hay.	Gloucester Fish Meal.	Wilcox Fish Guano.	Molassine Meal.	CXX Feed.	Mellen's Food Refuse.	Waste.	Feces.
I.	88.62	-	-	-	-	-	-	-	-	92.75
II.	88.32	86.55	-	-	-	-	-	-	-	93.31
VIII.	-	-	88.97	-	-	-	-	-	90.12	95.45
X.	90.75	88.36	-	94.28	-	-	-	-	-	93.32
XII.	89.25	87.57	-	-	91.62	-	-	-	-	93.18
Sheep V.										
IX.	90.07	-	-	-	-	-	90.82	-	-	93.63
XI.	89.82	-	-	-	-	81.94	-	-	-	94.08
XIII.	90 00	-	-	-	-	-	-	93.02	-	94.18
XIV.	-	-	89.85	-	-	-	-	-	-	92.93
Sheep VI.										
IX.	90.07	-	-	-	-	-	90.82	-	-	93.71
XI.	89.82	-	-	-	-	81.94	-	-	-	94.04
XIII.	90.00	-	-	-	-	-	-	93.02	-	93.99

Average Daily Amount of Manure excreted and Water drunk (Grams).

Sheep I.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	English hay,	648	25.83	2,586
II.	Corn meal,	426	21.02	1,660
VIII.	Brook Farm hay,	781	25.46	2,235
X.	Gloucester fish meal,	658	27.16	3,860
XII.	Wilcox fish guano,	538	24.41	2,965
XIV.	Molassine meal,	712	26.55	2,926
Sheep II.				
I.	English hay,	584	27.05	2,413
II.	Corn meal,	497	22.79	2,126
VIII.	Brook Farm hay,	789	27.96	2,668
X.	Gloucester fish meal,	537	24.33	3,596
XII.	Wilcox fish guano,	694	25.02	3,248

Average Daily Amount of Manure excreted and Water drunk (Grams) — Concluded.

Sheep V.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
IX.	CXX Feed, Postum Cereal refuse, . .	827	31.68	1,696
XI.	Molassine meal, ...	549	24.20	1,848
XIII.	Mellen's Food refuse, ...	778	29.72	2,238
XIV.	Brook Farm hay, ...	752	30.95	3,051

Sheep VI.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
IX.	CXX Feed, Postum Cereal refuse, . .	772	33.02	2,915
XI.	Molassine meal, ...	684	26.88	3,351
XIII.	Mellen's Food refuse, ...	946	31.26	3,801

Weights of Animals for Two Days at Beginning and Two Days at the End of Period (Pounds).

Sheep I.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	English hay, ...	143.00	143.00	145.50	144.75
II.	Corn meal, ...	140.00	139.50	140.75	141.00
VIII.	Brook Farm hay, ...	134.50	135.00	136.25	136.00
X.	Gloucester fish meal, ...	131.50	134.50	136.00	136.00
XII.	Wilcox fish guano, ...	138.75	138.25	140.25	140.25
XIV.	Molassine meal, ...	136.00	135.00	135.75	135.25

Sheep II.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	English hay, ...	142.50	142.50	141.50	141.50
II.	Corn meal, ...	137.75	137.50	136.00	136.00
VIII.	Brook Farm hay, ...	135.75	136.00	135.25	135.00
X.	Gloucester fish meal, ...	135.25	135.75	137.00	137.50
XII.	Wilcox fish guano, ...	139.00	139.00	138.25	139.00

Weights of Animals for Two Days at Beginning and Two Days at the End of Period (Pounds) — Concluded.

Sheep V.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
IX.	CXX Feed, Postum Cereal refuse,	166.25	166.50	163.00	163.00
XI.	Molassine meal,	160.25	160.25	157.50	157.75
XIII.	Mellen's Food refuse,	168.50	168.50	158.50	158.75
XIV.	Brook Farm hay,	156.75	156.00	160.75	157.75

Sheep VI.

Period.	Character of Food or Ration.	Beginning. First Weight.	Beginning. Second Weight.	End. First Weight.	End. Second Weight.
IX.	CXX feed, Postum Cereal refuse,	158.25	159.25	157.25	156.25
XI.	Molassine meal,	154.00	154.00	155.75	154.75
XIII.	Mellen's Food refuse,	155.00	155.00	154.75	153.75

English Hay, Period I.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	708.96	34.74	69.12	223.04	361.22	20.84
258.27 grams manure excreted,	238.90	23 24	27.16	63.38	115.52	9.60
Grams digested,	470.06	11.50	41.96	159.66	245.70	11.24
Per cent. digested,	66.30	33.10	60.42	71.58	68.02	53.93

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	708.96	34.74	69.12	223.04	361.22	20.84
270.48 grams manure excreted,	250.87	24.66	26.59	68.94	120.62	10.06
Grams digested,	458.09	10.08	42.53	154.10	240.60	10.78
Per cent. digested,	64.61	29.02	61.53	69.09	66.61	51.73
Average per cent. for both sheep,	65.46	31.06	60.98	70.34	67.32	52.83

Average nutritive ratio of rations for both sheep, 1:10.0.

English Hay, Corn Meal, Period II.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams English hay fed,	574.08	33.18	54.88	180.72	289.63	15.67
125 grams corn meal fed,	108.19	1.50	11.62	3.00	86.63	5.44
Amount consumed,	682.27	34.68	66.50	183.72	376.26	21.11
210.20 grams manure excreted,	195.53	18.24	24.38	50.62	94.18	8.11
Grams digested,	486.74	16.44	42.12	133.10	282.08	13.00
Per cent. digested,	71.34	47.40	63.34	72.45	74.97	61.58

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	682.27	34.68	66.50	183.72	376.26	21.11
227.87 grams manure excreted,	212.63	21.52	24.84	56.83	100.11	9.33
Grams digested,	469.64	13.16	41.66	126.89	276.15	11.78
Per cent. digested,	68.83	37.95	62.65	69.07	73.39	55.80
Average per cent. for both sheep,	70.09	42.68	63.00	70.76	74.18	58.69

Average nutritive ratio of rations for both sheep, 1:11.6.

Brook Farm Hay, Period VIII.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams Brook Farm hay fed,	711.76	45.98	58.86	241.22	350.97	14.73
87.43 grams waste,	78.79	3.69	3.59	30.01	40.66	.84
Amount consumed,	632.97	42.29	55.27	211.21	310.31	13.89
254.57 grams manure excreted,	242.40	21.91	28.17	63.78	120.54	8.00
Brook Farm hay digested,	390.57	20.38	27.10	147.43	189.77	5.89
Per cent. digested,	61.70	48.19	49.03	69.80	61.15	42.40

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams Brook Farm hay fed,	711.76	45.98	58.86	241.22	350.97	14.73
77.14 grams waste,	69.55	4.24	5.06	23.27	35.80	1.18
Amount consumed,	642.21	41.74	53.80	217.95	315.17	13.55
279.58 grams manure excreted,	266.86	22.87	26.34	76.30	133.10	8.25
Brook Farm hay digested,	375.35	18.87	27.46	141.65	182.07	5.30
Per cent. digested,	58.45	45.21	51.04	64.99	57.77	39.11
Average per cent. for both sheep,	60.08	46.70	50.04	67.40	59.96	40.76

Average nutritive ratio of rations for both sheep, 1:12.5.

CXX Feed, Postum Cereal Refuse, Period IX.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	495.39	32.35	46.32	159.02	243.38	14.32
250 grams CXX Feed fed,	227.05	6.22	44.43	41.12	128.20	7.08
Amount consumed,	722.44	38.57	90.75	200.14	371.58	21.40
316.80 grams manure excreted,	296.62	24.86	51.82	85.37	125.23	9.34
Grams digested,	425.82	13.71	38.93	114.77	246.35	12.06
Minus hay digested,	322.00	14.88	30.11	106.54	163.06	6.59
CXX Feed digested,	103.82	–	8.82	8.23	83.29	5.47
Per cent. digested,	45.73	–	19.85	20.01	64.97	77.26

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	722.44	38.57	90.75	200.14	371.58	21.40
330.20 grams manure excreted,	309.43	25.87	51.86	90.82	131.63	9.25
Grams digested,	413.01	12.70	38.89	109.32	239.95	12.15
Minus hay digested,	322.00	14.88	30.11	106.54	163 06	6.59
CXX Feed digested,	91.01	–	8.78	2.78	76.89	5.56
Per cent. digested,	40.08	–	19.76	6.76	59.98	78.53
Average per cent. for both sheep,	42.91	–	19.81	13.39	62 48	77.90

Average nutritive ratio of rations for both sheep, 1:9.8.

Gloucester Fish Meal, Period X.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams English hay fed,	589.88	37.81	57.81	187.82	290.87	15.57
125 grams corn meal fed,	110.45	1.61	12 07	2.87	88.53	5.37
100 grams Gloucester fish meal fed,	94.28	22.64	68.98	–	–	2.66
Amount consumed,	794.61	62.06	138.86	190.69	379.40	23.60
271.60 grams manure excreted,	254.00	38.86	44.35	55.04	107.11	8.64
Grams digested,	540.61	23.20	94 51	135.65	272.29	14.96
Minus hay and corn meal digested,	490.23	16.95	44.02	135.39	280.76	12.35
Gloucester fish meal digested,	50.38	6.25	50.49	.26	–	2 61
Per cent. digested,	53.44	27.61	73 20	–	–	98.12

Gloucester Fish Meal, Period X — Concluded.

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	794.61	62.06	138.86	190.69	379.40	23.60
243.33 grams manure excreted,	227.08	38.42	41.67	46.07	92.45	8.47
Grams digested,	567.53	23.64	97.19	144.62	286.95	15.13
Minus hay and corn meal digested,	490.23	16.95	44.02	135.39	280.76	12.35
Gloucester fish meal digested,	77.30	6.69	53.17	9.23	6.19	2.78
Per cent. digested,	81.99	29.55	77.08	–	–	104.51
Average per cent. for both sheep,	67.72	28.58	75.14	–	–	101.32

Average nutritive ratio of rations for both sheep, 1:5.2.

Molassine Meal, Period XI.

Sheep V.

550 grams English hay fed,	494.01	33.20	48.02	156.35	243.65	12.79
200 grams Molassine meal fed,	163.88	15.40	17.72	12.36	117.53	.87
Amount consumed,	657.89	48.60	65.74	168.71	361.18	13.66
241.96 grams manure excreted,	227.64	19.94	28.77	60.87	109.41	8.65
Grams digested,	430.25	28.66	36.97	107.84	251.77	5.01
Minus hay digested,	321.11	15.27	31.21	104.75	163.25	5.88
Molassine meal digested,	109.14	13.39	5.76	3.09	88.52	–
Per cent. digested,	66.60	86.95	32.51	25.00	75.32	–

Sheep VI.

600 grams English hay fed,	538.92	36.22	52.38	170.57	265.79	13.96
200 grams Molassine meal fed,	163.88	15.40	17.72	12.36	117.53	.87
Amount consumed,	702.80	51.62	70.10	182.93	383.32	14.83
268.78 grams manure excreted,	252.76	22.82	31.70	67.49	121.65	9.10
Grams digested,	450.04	28.80	38.40	115.44	261.67	5.73
Minus hay digested,	350.30	16.66	34.05	142.82	178.08	6.42
Molassine meal digested,	99.74	12.14	4.35	–	83.59	–
Per cent. digested,	60.86	78.83	24.55	–	71.12	–
Average per cent. for both sheep,	63.73	82.89	28.53	–	73.22	–

Average nutritive ratio of rations for both sheep, 1:9.4.

Wilcox Fish Guano, Period XII.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams English hay fed,	580.13	37.65	55.81	183.55	287.22	15.90
125 grams corn meal fed,	109.46	1.64	11.80	2.98	87.73	5.31
100 grams Wilcox fish guano fed,	91.62	17.36	57.42	–	–	9.30
Amount consumed,	781.21	56.65	125.03	186.53	374.95	30.51
244.11 grams manure excreted,	227.24	32.59	33.50	52.92	100.64	7.59
Grams digested,	553.97	24.06	91.53	133.61	274.31	22.92
Minus hay and corn meal digested,	482.71	16.89	42.59	132.44	277.46	12.51
Fish guano digested,	71.26	7.17	48.94	1.17	–	10.41
Per cent. digested,	77.78	41.30	85.23	–	–	111.96

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	781.21	56.65	125.03	186.53	374.95	30.51
250.16 grams manure excreted,	233.10	35.80	38.25	49.79	100.94	8.32
Grams digested,	548.11	20.85	86.78	136.74	274.01	22.19
Minus hay and corn meal digested,	482.71	16.89	42.59	132.44	277.46	12.51
Fish guano digested,	65.40	3.96	44.19	4.30	–	9.68
Per cent. digested,	71.38	22.81	76.96	–	–	104.09
Average per cent. for both sheep,	74.58	32.06	81.10	–	–	108.03

Average nutritive ratio of rations for both sheep, 1:5.15.

Mellen's Food Refuse, Period XIII.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	495.00	31.68	43.56	160.63	245.17	13.96
250 grams Mellen's Food refuse fed,	232.55	10.19	31.42	42.42	138.68	9.84
Amount consumed,	727.55	41.87	74.98	203.05	383.85	23.80
297.21 grams manure excreted,	279.91	28.89	30.76	77.26	133.82	9.18
Grams digested,	447.64	12.98	44.22	125.89	250.03	14.62
Minus hay digested,	321.75	14.57	28.31	107.62	164.26	6.42
Grams Mellen's Food refuse digested,	125.89	–	15.91	18.17	85.77	8.20
Per cent. digested,	54.13	–	50.64	42.83	61.85	83.33

Mellen's Food Refuse, Period XIII — Concluded.

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	727.55	41.87	74.98	203.05	383.85	23.80
312.56 grams manure excreted,	293.78	30.96	34.34	75.82	143.49	9.17
Grams digested,	433.77	10.91	40.64	127.23	240.36	14.63
Minus hay digested,	321.75	14.57	28.31	107.62	164.26	6.42
Grams Mellen's Food refuse digested,	112.02	–	12.33	19.61	76.10	8.21
Per cent. digested,	48.17	–	39.24	46.23	54.87	83.43
Average per cent. for both sheep,	51.15	–	44.94	44.53	58.36	83.38

Average nutritive ratio of rations for both sheep, 1:9.52.

Molassine Meal, Period XIV.

Sheep I.

600 grams English hay fed,	537.60	34.78	47.85	171.44	268.53	15.00
200 grams Molassine meal fed,	161.62	15.31	20.19	12.59	112.56	.97
Amount fed,	699.22	50.09	68.04	184.03	381.09	15.97
11.95 grams waste,	8.93	1.21	1.01	1.48	5.10	.13
Amount consumed,	690.29	48.88	67.03	182.55	375.99	15.84
265.45 grams manure excreted,	244.74	28.10	32.35	60.70	115.81	7.78
Grams digested,	445.55	20.78	34.68	121.85	260.18	8.06
Minus hay digested,	349.44	10.78	29.19	120.01	179.92	7.95
Molassine meal digested,	96.11	10.00	5.49	1.84	80.26	.11
Per cent. digested,	59.47	65.31	27.19	14.61	71.30	11.34

Average nutritive ratio of ration, 1:11.5.

Brook Farm Hay, Period XIV.

Sheep V.

750 grams Brook Farm hay fed,	669.38	42.30	59.57	215.00	318.25	14.26
309.50 grams manure excreted,	287.62	27.73	29.37	86.49	135.23	8.80
Grams digested,	381.76	14.57	30.20	128.51	183.02	5.46
Per cent. digested,	57.03	34.44	50.70	59.77	57.51	38.29

Average nutritive ratio of ration, 1:10.7.

4. Series XIX.

Digestion Coefficients of Basal Ration used in this Series.

	English Hay.	English Hay and Gluten Feed.
Dry matter,	65	66
Ash,	46	31
Protein,	65	68
Fiber,	67	66
Nitrogen-free extract,	67	70
Fat,	46	56

Composition of Feedstuffs (Per Cent.).

[Dry Matter.]

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay,	6.19	10.01	30.58	50.63	2.59
I.	Gluten feed,	1.10	27.75	8.78	58.00	4.37
I.	Molassine meal,	8.63	11.29	11.09	68.26	.73
II.	English hay,	5.83	9.52	31.40	50.98	2 27
II.	Gluten feed,	1.05	27.84	8.75	57.78	4.58

Composition of Feces (Per Cent.).

[Dry Matter.]

Sheep V.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	Molassine meal,	8.82	12.68	28.90	46.58	3.02
II.	English hay and gluten feed,	9.25	12.79	27.62	46.75	3.59

Sheep VI.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	Molassine meal,	8.65	12.57	27.34	48.27	3.17
II.	English hay and gluten feed,	10.47	12.62	26.49	46.81	3.61

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.).

Sheep V.

Period.	English Hay.	Gluten Feed.	Molassine Meal.	Feces.
I.,	86.45	89.78	83.41	90.92
II.,	88.02	89.55	-	92.47

Sheep VI.

Period.	English Hay.	Gluten Feed.	Molassine Meal.	Feces.
I.,	86.45	89.78	83.41	90.88
II.,	88.02	89.55	-	92.59

Average Daily Amount of Manure excreted and Water drunk (Grams).

Sheep V.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	Molassine meal,	676	30.43	2,771
II.	English hay and gluten feed,	470	22.65	2,589

Sheep VI.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	Molassine meal,	627	29.35	1,899
II.	English hay and gluten feed,	465	22.30	1,183

Weights of Animals for Two Days at Beginning and Two Days at End of Period (Pounds).

Sheep V.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	Molassine meal,	133.25	131.75	131.50	132.25
II.	English hay and gluten feed,	132.75	131.50	129.75	130.00

Sheep VI.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	Molassine meal,	156.75	157.50	159.50	-
II.	English hay and gluten feed,	157.25	158.50	155.25	152.75

Molassine Meal, Period I.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	475.48	29.43	47.60	145.40	240.74	12.31
150 grams gluten feed fed,	134.67	1.48	37.37	11.82	78.11	5.89
200 grams Molassine meal fed,	166.82	14.40	18.83	18.50	113.87	1.22
Amount consumed,	776.97	45.31	103.80	175.72	432.72	19.42
304.25 grams manure excreted,	276.62	24.40	35.08	79.94	128.85	8.35
Grams digested,	500.35	20.91	68.72	95.78	303.87	11.07
Minus English hay and gluten feed digested.	402.70	9.58	57.78	103.77	223.20	10.19
Molassine meal digested,	97.65	11.33	10.94	–	80.67	.88
Per cent. digested,	58.54	78.47	58.10	–	70.84	72.13

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	776.97	45.31	103.80	175.72	432.72	19.42
293.54 grams manure excreted,	266.77	23.08	33.53	72.93	128.77	8.46
Grams digested,	510.20	22.23	70.27	102.79	303.95	10.96
Minus English hay and gluten feed digested.	402.70	9.58	57.78	103.77	223.20	10.19
Molassine meal digested,	107.50	12.65	12.49	–	80.75	.77
Per cent. digested,	64.44	87.85	66.33	–	70.91	63.11
Average per cent. for both sheep,	61.49	83.16	62.22	–	70.88	67.62

Average nutritive ratio of rations for both sheep, 1:6.15.

English Hay, Gluten Feed, Period II.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	484.11	28.22	46.09	152.01	246.80	10.99
150 grams gluten feed fed,	134.33	1.41	37.40	11.75	77.62	6.15
Amount consumed,	618.44	29.63	83.49	163.76	324.42	17.14
226.53 grams manure excreted,	209.47	19.38	26.79	57.86	97.92	7.52
Grams digested,	408.97	10.25	56.70	105.90	226.50	9.62
Per cent. digested,	66.13	34.59	67.91	64.67	69.82	56.13

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	618.44	29.63	83.49	163.76	324.42	17.14
223.00 grams manure excreted,	206.48	21.62	26.06	54.70	96.65	7.45
Grams digested,	411.96	8.01	57.43	109.06	227.77	9.69
Per cent. digested,	66.61	27.03	68.79	66.60	70.21	56.53
Average per cent. for both sheep,	66.37	30.81	68.35	65.64	70.02	56.33

Average nutritive ratio of rations for both sheep, 1:6.23.

5. Discussion of Results.

Owing to the fact that a number of the tests were repeated in a series following, the coefficients secured for each feed in the several series are brought together and discussed below.

English Hay.

But two different lots of hay were used in all of these experiments. It consisted of mixed grasses with June grass (*Poa pratensis*) predominating; cut while in blossom, well cured and in good condition. Before feeding it was cut fine by running it through a feed cutter, and thoroughly mixed to insure uniformity through the entire lot.

Summary of Coefficients, English Hay, Series XVI., Period I.; Series XVII., Periods I. and VIII.; Series XVIII., Period I.

Lot.	Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	I.,	1	1	62.92	32.24	54.53	69.00	65.85	54.06
	II.,	1	1	59.36	27.27	52.79	62.91	63.51	54.68
	V.,	1	1	61.39	31.98	53.98	66.67	64.62	48.25
	VI.,	1	1	63.03	35.61	56.42	68.98	65.50	47.48
	Average,	1	4	61.68	31.78	54.43	66.89	64.87	51.12
II.	I.,	1	1	66.30	33.10	60.42	71.58	68.02	53.93
	II.,	1	1	64.61	29.02	61.53	69.09	66.61	51.73
	V.,	1	1	64.22	47.52	64.46	66.37	66.00	48.83
	VI.,	1	1	65.41	44.08	64.88	68.36	67.93	42.70
	Average,	1	4	65.14	38.43	62.82	68.85	67.14	49.30
	Average of all trials of similar hay for comparison.	21	73	61.00	47.00	57.00	62.00	62.00	50.00

The first lot of hay was somewhat less digestible than was the second lot, probably due to the stage of growth at time of cutting. The digestion coefficients compare quite closely with those obtained in previous experiments with similar hay.

Dried Beet Pulp and Molasses Dried Beet Pulp.

Both of these products are the dried residue from the manufacture of sugar from the sugar beet. Molasses dried beet pulp differs from the plain dried beet pulp in containing a considerable proportion of the residual molasses, probably about 25 per cent. The first-named product is noticeably darker in color.

Summary of Coefficients, Dried Beet Pulp, Series XVI., Period III.; Series XVII., Period V.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.,	1	1	76.72	32.56	49.97	83.56	90.00	-
II.,	1	1	71.45	18.59	55.47	67.03	86.84	-
III.,	1	1	75.56	-	50.14	99.76	73.59	-
Average,	1	3	74.58	-	51.86	83.45	83.48	-

Summary of Coefficients, Molasses Dried Beet Pulp, Series XVI., Period II.; Series XVII., Period V.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.,	1	1	84.64	55.96	59.87	88.63	91.02	-
II.,	1	1	79.57	36.01	50.19	77.77	89.23	-
IV.,	1	1	82.80	61.06	73.53	64.56	91.37	-
Average,	1	3	82.34	51.01	61.20	76.99	90.54	-

The digestibility of the molasses pulp was about 8 per cent. higher than that of the plain pulp, due to the molasses which is, in all probability, entirely digestible. While beet pulp contains 15 to 18 per cent. of fiber, its digestibility is much higher than that of wheat bran or ground oats, due to its soft, unlignified character. For Sheep III. in the experiment with plain beet pulp, the fiber digestibility is very high, with a corresponding depression in the digestibility of the nitrogen-free extract. It is believed that this condition is abnormal, and that the average of the coefficients for Sheep I. and II. would be more accurate. The digestibility of the ash in the plain pulp is uncertain, due, partly at least, to the small amount present. There being only about ½ per cent. of ether extract (fat) in beet pulp, it is not possible to secure digestion coefficients for that ingredient. From the variations noted in the digestibility of the different ingredients it is evident that the several sheep differed in their ability to make use of the different nutrients.

Cocoanut Meal.

This product is the residue from the manufacture of cocoanut oil, and is used largely in European countries. It contains about 20 per cent. of protein and 8 to 10 per cent. of fat and some 9 to 10 per cent. of fiber. The sample used was purchased from the Edible Oils Company of New York.

Summary of Coefficients, Cocoanut Meal, Series XVII., Periods II. and VII.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	1	1	78.34	63.63	89.59	-	84.59	102.41
VI.,	1	2	83.74	64.24	89.92	23.36	88.56	102.91
Average,	1	3	81.94	64.04	89.81	-	87.24	102.74
European results,[1]	3	5	80.00[2]	-	78.00	63.00	83.00	97.00

[1] Kellner's tabulation. [2] Organic matter.

This material shows a somewhat higher digestibility than the average of European trials, due partly to its less fiber content.

The digestibility of the fiber varied to such an extent as to warrant the elimination of the fiber coefficient, Sheep V. showing a slightly negative result, and the two trials with Sheep VI. showing 7.01 and 39.71 per cent., respectively. It seems probable that the addition of the cocoanut meal to the hay improved the digestibility of the hay fiber, which accounts for the apparently negative or variable fiber coefficients of the cocoanut meal. The ash, protein, extract matter and fat all show a high digestibility, and indicate this material to be a valuable protein concentrate.

Cottonseed Feed Meal, Creamo Brand.

This product consists of a mixture of high-grade cottonseed meal and cottonseed hull bran, the latter being the cottonseed hull from which the lint has been removed.

Summary of Coefficients, Cottonseed Feed Meal, Creamo Brand, Series XVII., Period III.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.	1	1	59.30	47.20	73.57	32.31	61.35	102.97
VI.,	1	1	57.15	51.53	76.34	19.88	61.04	98.25
Average,	1	2	58.23	49.37	74.96	26.10	61.20	100.66
High-grade cottonseed meal for comparison.	4	12	79.00	84.00	84.00	35.00	78.00	94.00

The digestion coefficients in this experiment agreed closely except for fiber. The fiber coefficient was, however, low in both instances, as was to be expected because of the tough, woody character of the hull. This material contains only about three-fourths of the total digestible dry matter of cottonseed meal of good quality. Furthermore, since it contains much less digestible protein, and two and one-half times as much total fiber as genuine cottonseed meal, it is not worth more than one-half as much for animal feeding. In fact, the northern farmer cannot afford to purchase it at present prices in place of the genuine article.

Wheat Screenings.

Wheat screenings consist of the light wheat seed, weed seeds, chaff and dirt separated from the grain as it comes to the mill in preparing the wheat for the manufacture of flour. Their composition depends upon the kind of seeds predominating and upon the amount of dirt and chaff present. They necessarily vary so much in composition that no general statement as to their nutritive value can be made, and the figures reported below should not be understood as applying to all wheat screenings. The two lots used in the present experiments were quite similar in appearance and chemical composition, and were free from an excessive amount of straw and chaff. In the first sample the following seeds and ingredients were identified: light oats, oat hulls, wheat, wheat refuse, smutted grain, yellow foxtail, green foxtail, corn cockle, bindweed, flax, lady's-thumb, charlock, wild mustard, rape, lamb's-quarters, large smartweed, chaff of various sorts, wild sunflower, pigweed, timothy, shepherd's-purse, chess, oat grass, wild oats, rye and corn, together with a few unidentified seeds. Screenings are found in the eastern markets principally as an ingredient of molasses feeds. Both lots were coarsely ground before feeding.

Summary of Coefficients, Wheat Screenings, Series XVII., Period IV. (Lot I.).

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	1	1	57.57	27.36	78.88	-	63.76	86.18
VI.,	1	1	60.65	26.10	82.97	-	65.33	87.41
Average,	1	2	59.11	26.73	80.93	-	64.55	86.80

Summary of Coefficients, Wheat Screenings, Series XVII., Period X. (Lot II.).

V.,	1	1	64.93	-	62.26	-	79.54	87.67
VI.,	1	1	68.58	-	63.01	-	84.12	92.50
Average,	1	2	66.76	-	62.64	-	81.83	90.09
Average for both trials,	2	4	62.94	-	71.79	-	73.19	88.45

The difference shown in the digestibility of the two lots can probably be accounted for by the fact that the first lot contained more fiber and less nitrogen-free extract than did the second. In both trials the fiber coefficient showed that slightly less fiber was digested than when the hay was fed alone, indicating somewhat of a depressing effect of the wheat screenings upon fiber digestibility, and also that the fiber contained in the screenings was of decidedly inferior character. The screenings contain a high ash content, but the small amount digested shows it to be of comparatively little value.

The experiment indicates that screenings, when finely ground and reasonably free from dirt, chaff and noxious seeds, possess considerable nutritive value. It is likely to be found primarily in the protein and extract matter of the screenings.

Flax Shives.

Flax shives, sometimes incorrectly called flax bran, consists of the ground refuse stalks and pods of the flax plant. It is found on the market as a component of some molasses and stock feeds.

Summary of Coefficients, Flax Shives, Series XVII., Period VI.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	1	1	42.94	21.86	79.98	22.00	41.27	92.26
VI.,	1	1	47.82	23.69	82.08	29.58	45.63	93.09
Average,	1	2	45.38	22.78	81.03	25.79	43.45	92.68

This experiment showed flax shives to have a digestibility of about 45 per cent. as compared with 66 per cent. for wheat bran. It contained nearly 35 per cent. of fiber of which about one-fourth proved digestible, and must be pronounced as distinctly inferior for feeding.

Cocoa Shells.

Cocoa shells are the hard, outside coating or bran of the cocoa bean. Up to the present time they have been used but little as a feedstuff, although their chemical composition would indicate that they have considerable feeding value. Preliminary feeding experiments have shown them to be rather unpalatable.

Summary of Coefficients, Cocoa Shells, Series XVII., Period IX.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.,	1	1	56.55	13.04	4.41	41.41	75.75	100.44
II.,	1	1	58.59	14.32	18.52	59.91	71.16	100.54
Average,	1	2	57.52	13.64	11.47	50.66	73.46	100.48

The coefficients for both sheep agree closely except for protein. In both cases, however, the protein coefficient is extremely low, due, perhaps, to the presence of considerable vegetable alkaloid. It is doubtful if they have more than one-half the value of corn meal. Their use will be more fully discussed elsewhere.

Brook Farm Hay.

This hay was purchased at the Brook Farm, just north of the station grounds, and consisted of a mixture of timothy, red top and clover in good condition. Sheep I. and II. left a considerable portion, Sheep I. refusing the finer portion and Sheep II. the coarser part. In a later trial Sheep V. was induced to eat the entire ration. It was used in connection with a feeding experiment.

Summary of Coefficients, Brook Farm Hay, Series XVIII., Periods VIII. and XIV.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.,	1	1	61.70	48.19	49.03	69.80	61.15	42.40
II.,	1	1	58.45	45.21	51.40	64.99	57.77	39.11
V.,	1	1	57.03	34.44	50.70	59.77	57.51	38.29
Average,	1	3	59.06	42.61	50.38	64.85	58.81	39.93
Average all trials, mixed hay for comparison.	5	10	55.00	30.00	47.00	65.00	59.00	45.00

The experiment shows this particular lot of hay to compare favorably with all previous trials of mixed hay composed of similar grasses.

CXX Feed.

This feed is a product from the Postum Cereal Company's works, and is probably the residue from the manufacture of Instant Postum, prepared by roasting a mixture of wheat, wheat bran and molasses.

Summary of Coefficients, CXX Feed, Series XVIII., Period IX.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	1	1	45.73	-	19.85	20.00	64.97	77.26
VI.,	1	1	40.08	-	19.76	6.76	59.98	78.53
Average,	1	2	42.91	-	19.81	13.39	62.48	77.90

The results of the experiment show the CXX Feed to have a very low digestibility, probably due to the roasting that the product undergoes. The protein and fiber appear to be of little nutritive value, and the material as a whole must be pronounced quite inferior for feeding purposes.

Fish Meals.

Two varieties of fish meal were used in these experiments. The first, Gloucester fish meal, was received from the Russia Cement Company, and is a by-product from the manufacture of fish glue. The second is a by-product from the menhaden fisheries, and up to the present time has been used almost entirely as a fertilizer. It had not been treated with sulphuric acid. The fish guano contained more fat and less ash and protein than did the Gloucester fish meal. In some European countries dried fish and even the raw refuse is used as a food for domestic animals.

Summary of Coefficients, Gloucester Fish Meal, Series XVIII., Period X.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.,	1	1	53.44	27.61	73.20	-	-	98.12
II.,	1	1	81.99	29.55	77.08	-	-	104.51
Average,	1	2	67.72	28.58	75.14	-	-	101.32

Summary of Coefficients, Wilcox Fish Guano, Series XVIII., Period XII.

I.,	1	1	77.78	41.30	85.23	-	-	111.96
II.,	1	1	71.38	22.81	76.96	-	-	104.09
Average,	1	2	74.58	32.06	81.10	-	-	108.03

The nutritive ratio of the basal ration of hay and corn meal was as 1:10. It would have been better had the basal ration consisted of hay and some nitrogenous concentrate with a ratio of 1:7 or thereabouts, for it is well known that a highly nitrogenous concentrate added to a basal ration with a wide nutritive ratio (1:8 or above) has a tendency to improve the digestibility of the fiber and extract matter of the latter, and would indicate an apparent increase in the digestibility of the fish.

Gloucester Fish Meal. — In case of Sheep I.,[1] the addition of the fish to the basal ration did not appear to improve the digestibility of the carbohydrates, although it may have had a favorable effect upon the protein of the basal ration. In case of Sheep II. it exerted a noticeably favorable effect upon both the fiber and extract, and perhaps upon the protein of the basal ration.

Wilcox Fish Guano. — Sheep II. did not digest as much of the bone (ash) as did Sheep I. The fish seemed to exert a slightly favorable effect upon the fiber, but an adverse effect upon the extract matter. The addition of the fish did improve the digestibility of the fat in the basal ration.

[1] The coefficients with this sheep were not satisfactory.

It is intended to repeat these experiments, using a basal ration with a narrower ratio.

The two samples of fish were composed of approximately 20 per cent. ash, from 60 to 70 per cent. protein, and 3 and 10 per cent. fat, respectively. Its chief value, from a nutritive standpoint, consists in the amount of digestible protein and fat. In view of the prices usually prevailing for fish, it is doubtful if it would prove particularly economical as a food for animals in place of nitrogenous concentrates of vegetable origin.

Molassine Meal.

This is an English product now being extensively sold in Massachusetts. It is composed of from 25 to 30 per cent. of sphagnum moss and from 70 to 75 per cent. of cane or beet molasses. The moss, according to the manufacturers, comes from the upper layers of large bogs in Yorkshire, Eng. Such material, as time passes, decays and forms peat. A sample of the dried sphagnum moss was found to analyze as follows: —

	Per Cent.
Water,	11.45
Protein,	2.72
Fat,	1.18
Nitrogen-free extract,	43.82
Fiber,	39.74
Ash,	1.09

It is doubtful if the moss has any particular nutritive properties;[1] hence, the nutritive value of the feed consists in the amount of molasses present. The larger part of the crude protein found in Molassine meal exists in the form of amids.

[1] Kellner and Pfeiffer have shown that peat is without nutritive value.

Summary of Coefficients, Molassine Meal, Series XVIII., Periods XI. and XIV.; Series XIX., Period I.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.,[1]	1	1	59.47	65.31	27.19	14.61	71.30	11.34
V.,[2]	1	1	58.54	78.47	58.10	–	70.84	72.13
V.,[1]	1	1	66.60	86.95	32.51	25.00	75.32	–
VI.,[2]	1	1	64.44	87.85	66.33	–	70.91	63.11
VI.,[1]	1	1	60.86	78.83	24.55	–	71.12	–
Average,	1	5	61.98	79.48	41.74	–	71.90	–

[1] Fed with English hay. [2] Fed with English hay and gluten feed.

In three trials the basal ration was English hay; in two other trials English hay and gluten feed were used. Inasmuch as it contains practically no fat, and that its nitrogen is in the amido form, its chief nutritive value is to be found in the carbohydrates. On the basis of the digestibility and at the same moisture content, Molassine meal would have scarcely two-thirds of the nutritive value of corn meal.[1]

Mellen's Food Refuse.

This material is sold to a limited extent in Massachusetts and consists of the residue resulting from the manufacture of an infant food. The original ingredients used in the food are barley, malt, flour and bran.

Summary of Coefficients, Mellen's Food Refuse, Series XVIII., Period XIII.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	1	1	54.13	–	50.64	42.83	61.85	83.33
VI.,	1	1	48.17	–	39.24	46.23	54.87	83.43
Average,	1	2	51.15	–	44.94	44.53	58.36	83.38

[1] See also Bulletin 146, p. 58.

Mellen's Food refuse shows a total digestibility only of about 51 per cent., which is lower than would be obtained for any of the ingredients used in the manufacture of the food. This is due, no doubt, to the fact that the more digestible parts are to be found in the food itself.

Complete Summary of All Coefficients (Per Cent.).

Food.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
English hay, Series XVI. and part of Series XVII.	I.,	62.92	32.24	54.53	69.00	65.85	54.06
	II.,	59.36	27.27	52.79	62.91	63.51	54.68
	V.,	61.39	31.98	53.98	66.67	64.62	48.25
	VI.,	63.03	35.61	56.42	68.98	65.50	47.48
Average,		61.68	31.78	54.43	66.89	64.87	51.12
English hay, part of Series XVII., Series XVIII. and XIX.	I.,	66.30	33.10	60.42	71.58	68.02	53.93
	II.,	64.61	29.02	61.53	69.09	66.61	51.73
	V.,	64.22	47.52	64.46	66.37	66.00	48.83
	VI.,	65.41	44.08	64.88	68.36	67.93	42.70
Average,		65.14	38.43	62.82	68.85	67.14	49.30
Dried beet pulp,	I.,	76.72	32.56	49.97	83.56	90.00	–
	II.,	71.45	18.59	55.47	67.03	86.84	–
	III.,	75.56	–	50.14	99.76	73.59	–
Average,		74.58	25.58	51.86	83.45	83.48	–
Molasses dried beet pulp,	I.,	84.64	55.96	59.87	88.63	91.02	–
	II.,	79.57	36.01	50.19	77.77	89.23	–
	IV.,	82.80	61.06	73.53	64.56	91.37	–
Average,		82.34	51.01	61.20	76.99	90.54	–
Cocoanut meal,	V.,	78.34	63.63	89.59	–	84.59	102.41
	VI.,	83.74	63.98	94.84	7.01	89.29	104.47
	VI.,	83.74	64.50	85.00	39.71	87.83	101.35
Average,		81.94	64.04	89.81	23.36	87.24	102.74
Cottonseed feed meal, Creamo brand,	V.,	59.30	47.20	74.28	32.31	61.35	102.97
	VI.,	57.15	51.53	76.34	19.88	61.04	98.25
Average,		58.23	49.37	75.31	26.10	61.20	100.61
Wheat screenings,	V.,	57.57	27.36	78.88	–	63.76	86.18
	VI.,	60.65	26.10	82.97	–	65.33	87.41
Average,		59.11	26.73	80.93	–	64.55	86.80
Wheat screenings,	V.,	64.93	–	62.26	–	79.54	87.67
	VI.,	68.58	–	63.01	–	84.12	92.50
Average,		66.76	–	62.64	–	81.83	90.09

Complete Summary of All Coefficients (Per Cent.) — Concluded.

Food.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Flax shives,	V.,	42.94	21.86	79.98	22.00	41.27	92.26
	VI.,	47.82	23.69	82.08	29.58	45.63	93.09
Average,	.	45.38	22.78	81.03	25.79	43.45	92.68
Cocoa shells,	I.,	56.55	13.04	4.41	41.41	75.75	100.41
	II.,	58.49	14.23	18.52	59.91	71.16	100.54
Average,	.	57.52	13.64	11.47	50.66	73.46	100.48
English hay and corn meal (5½ to 1),[1]	I.,	71.34	47.40	63.34	72.45	74.97	61.58
	II.,	68.83	37.95	62.65	69.07	73.39	55.80
Average,	.	70.09	42.68	63.00	70.76	74.18	58.69
Brook Farm hay,	I.,	61.70	48.19	49.03	69.80	61.15	42.40
	II.,	58.45	45.21	51.40	64.99	57.77	39.11
	V.,	57.03	34.44	50.70	59.77	57.51	38.29
Average,	.	59.06	42.61	50.38	64.85	58.81	39.93
CXX Feed, Postum Cereal refuse,	V.,	45.73	–	19.85	20.01	64.97	77.26
	VI.,	40.08	–	19.76	6.76	59.98	78.53
Average,	.	42.91	–	19.81	13.39	62.48	77.90
Gloucester fish meal,	I.,	53.44	27.61	73.20	–	–	98.12
	II.,	81.99	29.55	77.08	–	–	104.51
Average,	.	67.72	28.58	75.14	–	–	101.32
Wilcox fish guano,	I.,	77.78	41.30	85.23	–	–	111.96
	II.,	71.38	22.81	76.96	–	–	104.09
Average,	.	74.58	32.06	81.10	–	–	108.03
Molassine meal,	I.,	59.47	65.31	27.19	14.61	71.30	11.34
	V.,	58.54	78.47	58.10	–	70.84	72.13
	V.,	66.60	86.95	32.51	25.00	75.32	–
	VI.,	64.44	87.85	66.33	–	70.91	63.11
	VI.,	60.86	78.83	24.55	–	71.12	–
Average,	.	61.98	79.48	41.74	–	71.90	–
Mellen's Food refuse,	V.,	54.13	–	50.64	42.83	61.85	83.33
	VI.,	48.17	–	39.24	46.23	54.87	83.43
Average,	.	51.15	–	44.94	44.53	58.36	83.38
English hay and gluten feed (550 to 150 grams).	V.,	66.13	34.59	67.91	64.67	69.82	56.13
	VI.,	66.61	27.03	68.79	66.60	70.21	56.53
Average,	.	66.37	30.81	68.35	65.64	70.02	56.33

[1] Parts by weight.

A SUMMARY OF METEOROLOGICAL RECORDS.

Location and Equipment.

The meteorological observatory is located in the tower at the southeast corner of South College, at an elevation of about 50 feet above the ground. It was equipped with a number of Draper self-recording instruments, and the records date from Jan. 1, 1889. The location is on a gravel ridge with an open exposure to the north, west and southwest, with slightly higher ground about a mile to the south and a ridge considerably higher about half a mile to the east.

The top of the tower is 72 feet above the ground, and the exposure is good in all directions. The anemometer, anemoscope, wind-pressure instrument and electrical sunshine recorder are mounted from 3 to 5 feet above the top of the tower, and the recording apparatus is in the room below. The thermometer shelter and rain gauges are on the campus about 300 feet southwest from the tower and on slightly lower ground.

The observatory is in latitude 42° 23′ 48.5″ N., longitude 72° 31′ 10″ W., and the base of the tower is 223 feet above mean low water, Boston harbor, as determined by levels connecting with those of the Boston & Maine Railroad. The standard barometer is of United States Weather Bureau pattern, reading to 1/500 of an inch, and the cistern is 273½ feet above sea level. The Draper self-recording barometer is mounted 1 foot higher.

The sunshine recorder of the Draper pattern was replaced by an electrical one from Friez in 1906, and the Draper anemometer by one of United States Weather Bureau pattern at about the same time. These records are received on a triple register, which also records the rainfall. The rain gauges are about 2 feet above ground and 218 feet above sea level. A United States Weather Bureau gauge is used in determining the precipitation, and the tipping bucket electrical recording gauge in determining the time and rate.

The Draper self-registering thermometer, Weather Bureau pattern, maximum and minimum thermometers and hygrometer are in a standard shelter about 4 feet above ground and 220 feet above sea level.

On Jan. 1, 1904, the time of making observations was changed from 7 A.M., 2 P.M. and 9 P.M. to 8 A.M. and 8 P.M., so as to conform with the practice of the United States Weather Bureau. This change should be noted in comparing the dew point and relative humidity before and after that date. Other data are probably not affected by the change.

Mean Barometer.

[Readings are reduced to freezing and sea level.]

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean Annual.
1889, . .	30.11	30.24	29.84	29.80	29.92	29.96	29.91	30.01	30.00	30.05	30.04	30.14	30.00
1890, . .	30.19	30.10	29.99	30.10	29.96	29.98	30.02	30.00	30.12	29.88	30.01	30.01	30.03
1891, . .	29.96	30.04	30.10	29.92	29.98	29.92	29.99	29.96	30.11	30.03	30.12	30.08	30.02
1892, . .	29.96	30.11	29.90	29.97	29.94	29.92	29.99	30.02	30.10	29.90	29.99	30.01	29.98
1893, . .	29.95	30.11	30.06	30.09	29.90	30.06	29.97	30.00	30.06	30.13	30.12	30.12	30.05
1894, . .	30.18	30.16	30.09	30.05	30.00	30.00	30.01	30.03	30.14	30.02	30.08	30.15	30.08
1895, . .	30.05	29.92	30.00	30.12	30.10	30.17	30.03	30.02	30.10	30.08	30.19	30.15	30.08
1896, . .	30.16	29.86	29.99	30.14	29.98	29.95	29.97	29.99	30.00	30.01	30.14	30.14	30.03
1897, . .	30.04	30.06	30.04	30.04	29.92	29.90	29.94	29.94	30.09	30.12	30.03	30.04	30.01
1898, . .	29.98	30.05	30.20	29.93	29.94	29.95	30.02	29.96	30.01	30.09	30.01	29.96	30.01
1899, . .	30.11	29.98	29.94	30.04	30.00	29.98	29.93	29.98	30.02	30.19	30.01	30.03	30.02
1900, . .	30.03	29.97	29.95	29.96	29.91	29.91	29.91	29.99	30.04	30.15	29.99	30.03	29.98
1901, . .	29.95	29.79	29.90	29.97	29.88	29.95	29.93	30.02	30.03	30.08	29.93	30.03	29.96
1902, . .	30.04	29.78	29.91	29.88	29.84	29.84	29.96	29.92	30.04	30.03	30.06	30.06	29.95
1903, . .	29.91	29.98	30.20	29.87	29.94	29.94	29.88	30.00	30.10	30.00	30.01	29.97	30.00
1904, . .	30.08	30.11	30.11	29.97	30.02	30.02	29.98	30.03	30.08	30.08	29.95	30.02	30.03
1905, . .	30.08	30.12	30.12	29.85	29.93	29.93	29.95	29.98	30.05	30.10	30.01	30.08	29.94
1906, . .	30.09	30.20	30.09	29.98	29.94	29.94	29.98	30.02	30.09	30.09	30.04	30.12	30.05
1907, . .	30.23	30.09	30.08	29.88	29.93	29.93	29.87	30.00	30.02	30.05	30.05	30.02	30.02
1908, . .	29.97	30.08	30.10	29.92	30.03	30.03	30.04	30.03	30.10	30.17	30.01	30.04	30.04
1909, . .	30.15	29.96	29.82	30.06	29.94	29.97	29.91	30.02	30.11	30.03	30.16	29.89	30.01
1910, . .	30.11	30.07	30.08	29.97	29.96	29.92	29.89	30.07	30.10	30.01	29.80	30.03	30.00
1911, . .	30.12	30.12	29.99	30.14	30.03	29.94	29.99	30.02	30.06	30.11	30.01	30.15	30.06
1912, . .	30.02	29.93	30.13	29.99	29.96	29.99	29.98	29.95	30.07	30.06	30.00	30.01	30.01
1913, . .	30.10	30.01	30.11	30.02	29.99	30.00	29.94	30.03	30.13	29.97	30.13	30.01	30.04
Mean, .	30.06	30.03	30.03	29.99	29.96	29.96	29.96	30.00	30.07	30.06	30.04	30.05	30.01

Range of Barometer (in Inches).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Range
1889, . .	1.62	1.51	1.58	1.16	.75	.97	.68	.66	.98	.96	1.31	1.75	1.81
1890, . .	1.50	1.35	1.08	1.08	.81	.58	.63	1.10	.69	1.09	.98	1.20	1.76
1891, . .	1.93	1.36	1.21	1.42	.79	.53	.74	.61	.73	1.11	1.56	1.22	2.05
1892, . .	1.38	1.65	1.16	1.02	.96	.84	.97	.55	.96	.98	1.00	1.01	1.65
1893, . .	1.53	1.83	1.27	1.25	1.16	.67	.68	.93	.81	1.37	1.16	1.53	1.92
1894, . .	1.89	1.65	1.04	.86	.93	.75	.57	.44	1.11	1.19	1.22	1.23	2.01
1895, . .	1.46	1.88	1.24	1.40	.84	.66	.51	.53	.68	1.09	1.47	1.78	2.27
1896, . .	.97	1.77	1.52	.96	.75	.83	.79	.59	.85	1.10	1.23	1.57	2.22
1897, . .	1.57	1.15	1.74	1.10	.76	.55	.72	.61	.73	1.12	1.48	1.42	1.76
1898, . .	1.43	1.63	1.17	.86	.76	.95	.81	.60	.82	1.19	1.25	1.39	1.75
1899, . .	1.70	1.41	1.54	.90	.60	.59	.51	.56	.88	.76	1.10	1.58	1.82
1900, . .	1.58	1.89	1.52	1.01	.99	.67	.73	.53	1.03	1.07	1.71	1.53	1.89
1901, . .	1.68	.97	1.17	1.19	.77	.61	.59	.51	1.00	1.22	1.14	1.13	1.68
1902, . .	1.49	1.41	1.55	1.04	.94	1.27	.58	.67	.78	1.25	1.12	1.34	1.89
1903, . .	1.49	1.55	1.19	1.15	.85	.97	.57	.77	.78	1.08	1.32	1.56	1.77
1904, . .	1.50	1.36	1.58	1.00	.75	.81	.73	.73	1.20	1.23	1.84	1.43	2.23
1905, . .	1.37	1.28	.89	1.15	.85	.83	.58	.72	.66	1.16	1.22	1.53	1.64
1906, . .	1.53	1.28	1.64	1.05	1.08	.77	.90	.72	1.03	1.41	1.05	1.30	1.70
1907, . .	1.34	1.27	1.39	1.42	.67	.71	.76	.71	.91	1.24	1.59	1.46	1.79
1908, . .	1.73	1.89	1.22	1.35	1.11	.65	.66	.68	.73	1.17	1.14	1.31	1.97
1909, . .	1.64	1.63	1.52	1.14	0.82	.68	.88	.97	.80	.97	1.24	1.54	1.91
1910, . .	1.76	1.40	1.11	.90	1.02	.83	.57	.82	.57	1.05	1.02	1.44	1.76
1911, . .	1.50	1.09	1.77	1.14	.97	.69	.74	.76	.85	1.04	1.24	1.20	1.77
1912, . .	1.60	1.75	1.43	1.32	.86	.64	.89	.77	.75	.87	1.17	1.46	1.98
1913, . .	2.18	.88	1.92	1.06	.87	.80	.65	.72	.83	1.38	1.65	1.34	2.33
Mean, .	1.57	1.47	1.38	1.12	.87	.75	.70	.69	.87	1.12	1.29	1.41	1.89

Maximum Barometer.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Maximum Annual.
1889, . .	30.82	30.97	30.66	30.54	30.40	30.54	30.35	30.45	30.40	30.52	30.67	30.96	30.97
1890, . .	30.94	30.72	30.56	30.57	30.32	30.28	30.27	30.28	30.42	30.41	30.35	30.61	30.94
1891, . .	30.62	30.69	30.57	30.56	30.44	30.22	30.37	30.27	30.45	30.67	30.74	30.55	30.74
1892, . .	30.67	30.72	30.45	30.53	30.43	30.39	30.50	30.24	30.42	30.43	30.44	30.53	30.72
1893, . .	30.61	30.83	30.63	30.65	30.32	30.36	30.25	30.30	30.45	30.65	30.70	30.92	30.92
1894, . .	30.77	30.89	30.57	30.52	30.50	30.33	30.31	30.24	30.63	30.42	30.73	30.53	30.89
1895, . .	30.61	30.44	30.52	30.70	30.55	30.51	30.33	30.29	30.41	30.67	30.73	30.83	30.83
1896, . .	30.56	30.49	30.62	30.60	30.48	30.42	30.49	30.39	30.40	30.62	30.86	30.94	30.94
1897, . .	30.77	30.70	30.88	30.61	30.36	30.28	30.33	30.18	30.40	30.67	30.60	30.60	30.88
1898, . .	30.61	30.64	30.76	30.34	30.33	30.35	30.44	30.26	30.41	30.46	30.53	30.52	30.76
1899, . .	30.92	30.53	30.49	30.39	30.29	30.25	30.24	30.31	30.47	30.50	30.54	30.66	30.92
1900, . .	30.67	30.75	30.59	30.48	30.38	30.19	30.16	30.25	30.35	30.52	30.64	30.51	30.75
1901, . .	30.69	30.34	30.43	30.52	30.20	30.24	30.29	30.28	30.51	30.66	30.37	30.58	30.69
1902, . .	30.66	30.27	30.50	30.28	30.43	30.46	30.29	30.26	30.38	30.52	30.48	30.75	30.75
1903, . .	30.62	30.48	30.65	30.46	30.54	30.39	30.17	30.42	30.42	30.40	30.70	30.60	30.70
1904, . .	30.90	30.67	30.96	30.50	30.37	30.35	30.26	30.42	30.62	30.57	30.57	30.54	30.96
1905, . .	30.70	30.62	30.60	30.37	30.38	30.19	30.15	30.27	30.41	30.58	30.63	30.86	30.86
1906, . .	30.78	30.95	30.92	30.45	30.49	30.35	30.46	30.38	30.50	30.63	30.42	30.77	30.95
1907, . .	30.75	30.78	30.59	30.41	30.34	30.22	30.18	30.35	30.39	30.60	30.59	30.45	30.78
1908, . .	30.59	30.83	30.59	30.52	30.31	30.40	30.26	30.34	30.45	30.59	30.45	30.61	30.83
1909, . .	30.75	30.53	30.36	30.60	30.29	30.26	30.27	30.39	30.52	30.52	30.74	30.58	30.75
1910, . .	30.87	30.80	30.50	30.40	30.40	30.24	30.18	30.37	30.34	30.47	30.40	30.78	30.87
1911, . .	30.66	30.64	30.72	30.71	30.40	30.24	30.26	30.30	30.41	30.59	30.48	30.57	30.72
1912, . .	30.59	30.47	30.70	30.62	30.31	30.31	30.35	30.29	30.37	30.46	30.50	30.61	30.70
1913, . .	30.73	30.44	30.88	30.56	30.39	30.43	30.19	30.41	30.58	30.52	30.72	30.47	30.88
Mean, .	30.71	30.65	30.62	30.52	30.39	30.33	30.29	30.32	30.44	30.55	30.58	30.65	30.83

Minimum Barometer.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Minimum Annual.
1889, . .	29.20	29.46	29.08	29.38	29.65	29.57	29.67	29.79	29.42	29.56	29.36	29.21	29.08
1890, . .	29.44	29.37	29.48	29.49	29.51	29.70	29.64	29.18	29.73	29.32	29.37	29.41	29.18
1891, . .	28.69	29.33	29.36	29.14	29.65	29.69	29.63	29.66	29.72	29.56	29.18	29.33	28.69
1892, . .	29.29	29.07	29.29	29.51	29.47	29.55	29.53	29.69	29.46	29.45	29.44	29.52	29.07
1893, . .	29.08	29.00	29.36	29.40	29.16	29.69	29.57	29.37	29.64	29.28	29.54	29.39	29.00
1894, . .	28.88	29.24	29.53	29.66	29.57	29.58	29.74	29.80	29.52	29.23	29.51	29.30	28.88
1895, . .	29.17	28.56	29.28	29.30	29.71	29.85	29.82	29.76	29.73	29.58	29.26	29.05	28.56
1896, . .	29.59	28.72	29.10	29.64	29.73	29.59	29.70	29.80	29.55	29.52	29.63	29.37	28.72
1897, . .	29.20	29.55	29.14	29.51	29.60	29.63	29.61	29.57	29.67	29.55	29.12	29.18	29.12
1898, . .	29.18	29.01	29.59	29.48	29.57	29.40	29.63	29.66	29.59	29.27	29.28	29.13	29.01
1899, . .	29.22	29.12	28.95	29.49	29.69	29.66	29.63	29.75	29.56	29.74	29.44	29.10	29.10
1900, . .	29.08	28.86	29.06	29.47	29.39	29.51	29.42	29.72	29.32	29.42	28.93	28.98	28.86
1901, . .	29.01	29.37	29.26	29.33	29.43	29.63	29.70	29.76	29.51	29.44	29.23	29.42	29.01
1902, . .	29.17	28.86	28.95	29.24	29.49	29.24	29.61	29.59	29.60	29.27	29.36	29.41	28.86
1903, . .	29.13	28.93	29.46	29.31	29.69	29.42	29.60	29.65	29.69	29.32	29.38	29.04	28.93
1904, . .	29.40	29.31	29.38	29.50	29.62	29.54	29.53	29.69	29.42	29.28	28.73	29.11	28.73
1905, . .	29.33	29.34	29.71	29.22	29.53	29.36	29.57	29.55	29.75	29.42	29.41	29.33	29.22
1906, . .	29.25	29.67	29.28	29.40	29.41	29.58	29.56	29.66	29.47	29.22	29.37	29.47	29.25
1907, . .	29.41	29.51	29.29	28.99	29.69	29.51	29.42	29.64	29.48	29.36	29.00	29.05	28.99
1908, . .	28.86	28.94	29.37	29.27	29.20	29.75	29.69	29.66	29.72	29.42	29.31	29.30	28.86
1909, . .	29.11	28.90	28.84	29.46	29.47	29.58	29.39	29.42	29.72	29.55	29.50	29.04	28.84
1910, . .	29.11	29.40	29.39	29.50	29.38	29.41	29.61	29.55	29.77	29.42	29.38	29.34	29.11
1911, . .	29.16	29.55	28.95	29.57	29.43	29.55	29.52	29.54	29.56	29.55	29.24	29.37	28.95
1912, . .	28.99	28.72	29.27	29.30	29.45	29.67	29.46	29.52	29.62	29.59	29.33	29.15	28.72
1913, . .	28.55	29.56	29.26	29.50	29.52	29.63	29.54	29.69	29.75	29.14	29.07	29.13	28.55
Mean, .	29.14	29.17	29.27	29.40	29.52	29.57	29.59	29.63	29.60	29.42	29.29	29.25	28.93

Mean Hourly Temperature.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, . .	32.9	23.9	37.9	49.3	61.4	67.7	69.5	65.5	61.9	46.5	41.9	35.0	49.5
1890, . .	32.1	31.7	31.9	46.5	57.1	65.3	69.8	67.2	59.7	48.5	38.0	22.9	47.6
1891, . .	27.6	29.6	33.7	49.4	57.3	66.6	68.2	70.2	65.3	49.9	39.7	38.3	49.7
1892, . .	25.3	28.4	33.1	48.7	56.1	70.3	72.2	70.0	60.6	50.8	39.3	28.5	48.6
1893, . .	19.0	25.7	33.4	44.7	58.7	69.0	71.4	71.0	58.1	53.9	40.1	28.2	47.8
1894, . .	28.7	25.5	41.6	47.9	58.7	69.4	73.5	69.3	64.8	52.1	36.4	28.5	49.7
1895, . .	25.0	22.3	33.0	46.9	61.3	70.5	69.3	70.4	63.8	48.1	41.1	29.0	48.4
1896, . .	23.2	30.0	29.4	49.2	62.4	65.0	70.7	68.2	59.3	46.4	41.9	25.3	49.3
1897, . .	24.2	25.1	32.9	46.5	57.1	61.8	70.5	66.0	59.8	49.9	36.9	28.8	46.6
1898, . .	21.8	26.3	39.6	43.0	55.6	66.0	70.9	69.7	63.0	51.1	37.3	26.2	47.5
1899, . .	23.3	21.8	30.6	46.1	55.7	67.4	70.1	68.0	59.7	51.1	37.0	30.8	46.8
1900, . .	25.5	24.6	29.5	46.9	55.4	67.1	70.6	70.1	63.8	54.5	41.3	30.6	48.3
1901, . .	23.7	20.1	33.1	46.8	56.2	68.0	72.5	69.9	62.1	50.1	33.4	26.4	46.9
1902, . .	22.9	25.5	40.5	47.3	57.0	63.5	67.8	66.1	60.3	50.7	42.8	23.5	47.3
1903, . .	24.3	27.3	42.6	46.9	59.2	59.6	68.9	62.0	61.3	51.1	34.3	22.5	46.7
1904, . .	14.3	17.7	31.0	42.5	60.1	65.0	69.8	66.4	59.8	47.2	33.0	19.6	43.9
1905, . .	20.4	17.7	33.1	45.6	56.9	64.4	71.1	65.8	59.1	49.9	36.3	29.8	45.8
1906, . .	29.6	23.8	28.3	45.1	56.7	66.1	70.1	70.5	64.0	50.5	38.5	24.2	47.3
1907, . .	22.4	16.5	35.2	41.5	51.8	63.9	70.0	66.1	61.3	45.6	37.6	30.5	45.2
1908, . .	25.7	20.5	34.7	45.1	59.2	67.6	72.5	66.6	62.9	51.3	38.0	27.1	47.6
1909, . .	25.7	28.1	32.4	44.4	55.5	66.4	68.7	66.5	60.5	47.7	41.3	24.7	46.8
1910, . .	25.5	23.9	39.1	50.6	56.1	63.8	72.1	67.1	61.1	51.7	36.4	21.7	47.4
1911, . .	27.4	23.3	31.5	43.7	61.9	64.5	73.7	67.8	60.2	48.5	36.7	32.7	47.6
1912, . .	14.6	20.7	30.5	45.2	58.1	65.0	71.6	66.4	61.2	52.4	40.0	32.9	46.5
1913, . .	33.6	22.7	37.9	47.6	55.6	66.4	71.4	69.5	59.7	54.7	41.6	31.3	49.3
Mean, .	24.7	24.1	34.1	46.3	57.6	66.0	70.7	67.9	61.3	50.2	38.6	28.0	47.5

Range of Temperature (in Degrees F.).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Range Annual.
1889, . .	48.0	49.0	40.0	46.0	50.0	44.0	31.0	37.0	41.0	43.0	41.0	57.5	92.0
1890, . .	57.0	54.5	69.0	57.5	48.5	47.5	54.0	47.0	52.0	52.0	51.0	48.5	100.5
1891, . .	52.5	60.0	57.5	61.5	62.0	60.0	48.5	47.5	55.5	69.0	60.5	51.5	100.0
1892, . .	66.5	53.5	54.5	58.5	56.0	54.0	52.0	44.0	49.0	54.5	53.0	47.0	104.5
1893, . .	63.0	54.5	48.0	48.5	57.0	52.5	49.5	57.0	51.0	57.0	52.0	64.0	109.0
1894, . .	52.0	66.0	56.0	63.0	56.0	55.5	50.0	54.0	56.0	43.0	55.0	55.0	115.0
1895, . .	50.0	55.0	44.0	56.0	62.5	51.0	54.0	52.0	64.0	51.0	57.0	68.0	105.0
1896, . .	53.0	67.0	52.0	67.5	62.5	51.0	41.0	55.0	57.5	49.0	54.0	62.0	111.0
1897, . .	51.0	59.0	60.5	60.0	48.0	47.5	36.0	43.0	59.5	63.5	58.0	62.5	102.5
1898, . .	65.5	73.0	45.5	54.0	46.0	50.0	56.5	46.5	58.5	59.5	56.0	60.0	115.5
1899, . .	70.5	61.0	42.0	61.0	55.5	51.0	47.0	51.0	51.5	61.5	40.5	59.0	114.5
1900, . .	56.0	64.0	46.0	59.0	67.5	54.0	51.0	53.0	53.5	61.0	55.0	57.5	104.0
1901, . .	55.0	48.5	57.0	58.5	50.5	57.5	52.0	33.5	59.0	51.0	54.0	70.5	111.0
1902, . .	47.5	49.0	48.5	57.5	61.0	49.0	45.0	44.0	51.5	51.5	47.5	64.0	106.0
1903, . .	57.5	68.0	57.0	62.0	68.0	48.5	52.5	42.0	60.5	55.0	68.5	61.5	109.0
1904, . .	66.0	56.0	68.0	50.5	48.0	51.5	48.0	49.5	58.5	59.5	49.0	47.0	120.5
1905, . .	64.0	59.5	76.0	57.0	50.5	54.0	47.0	47.5	53.0	59.0	50.0	51.5	106.0
1906, . .	56.5	57.5	60.5	53.5	58.5	50.5	43.5	43.0	59.5	53.5	43.5	48.5	98.5
1907, . .	78.0	61.5	74.0	49.0	65.0	57.0	46.0	55.0	49.0	52.5	40.5	50.5	119.5
1908, . .	58.5	68.0	62.0	66.0	55.0	55.5	50.5	51.5	55.0	67.5	39.5	63.5	108.0
1909, . .	61.0	57.5	41.0	61.0	49.0	51.5	51.0	56.0	48.0	61.0	53.5	60.0	102.5
1910, . .	65.0	60.5	65.5	56.0	53.0	53.0	48.5	44.5	48.0	65.0	46.0	49.0	106.0
1911, . .	49.0	54.5	56.5	68.0	67.5	45.0	55.0	50.0	55.0	48.5	48.0	52.0	107.0
1912, . .	64.0	66.0	59.5	54.0	55.5	55.0	57.5	50.0	51.0	56.5	48.5	62.0	117.5
1913, . .	48.5	59.5	73.0	62.0	58.5	55.0	59.0	56.0	56.5	54.5	45.0	48.0	104.5
Mean, .	58.2	59.3	56.5	57.9	56.5	52.0	49.0	48.4	54.1	56.0	50.7	56.8	107.6

Maximum Temperatures (in Degrees F.).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Maximum Annual.
1889, . .	56.0	47.0	61.0	78.0	88.0	90.0	85.0	82.0	81.0	69.0	61.0	63.0	90.0
1890, . .	61.5	57.5	62.5	79.5	80.0	88.0	94.0	88.5	80.5	78.0	62.5	43.5	94.0
1891, . .	52.0	54.0	56.5	79.5	87.0	94.0	90.0	92.5	91.5	89.0	64.0	60.5	94.0
1892, . .	57.0	46.5	60.5	78.5	84.0	95.0	94.0	94.0	80.0	77.5	67.0	46.0	95.0
1893, . .	50.0	50.0	52.0	67.5	87.0	94.0	90.5	96.0	81.0	80.0	63.0	52.0	96.0
1894, . .	53.0	49.0	73.0	79.0	85.0	93.0	98.0	91.0	91.0	75.0	65.0	51.0	98.0
1895, . .	45.5	45.0	49.0	81.0	92.0	95.0	90.0	90.0	97.0	71.0	72.0	65.0	97.0
1896, . .	41.0	53.0	57.0	88.5	94.5	90.0	91.0	97.0	88.5	72.0	69.0	52.5	97.0
1897, . .	51.0	48.0	59.0	80.5	79.5	85.5	91.0	85.0	91.5	84.0	63.0	59.0	91.5
1898, . .	50.0	54.0	60.0	71.0	78.5	89.5	96.5	91.0	93.0	86.5	62.0	48.0	96.5
1899, . .	49.0	51.0	52.0	82.0	88.5	93.0	90.0	92.0	84.0	82.0	58.0	61.0	93.0
1900, . .	51.5	56.0	49.0	80.8	91.5	94.0	95.5	96.0	89.0	83.0	67.0	58.0	96.0
1901, . .	47.0	44.0	56.5	86.5	82.0	98.5	100.5	86.5	92.0	75.0	60.0	60.0	100.5
1902, . .	47.0	54.0	65.0	83.0	91.0	89.0	90.0	87.0	86.5	74.0	65.0	49.0	91.0
1903, . .	45.5	57.0	76.0	84.0	92.5	86.5	97.0	84.5	91.0	77.5	74.5	52.0	97.0
1904, . .	40.0	48.0	65.0	70.5	85.0	92.5	94.5	89.5	84.5	77.5	56.5	43.5	94.5
1905, . .	51.0	48.5	77.0	79.0	82.5	90.0	93.0	89.0	85.0	80.5	61.0	54.5	93.0
1906, . .	60.0	52.5	53.0	74.5	90.0	87.5	88.5	90.5	91.0	77.5	62.0	45.5	91.0
1907, . .	54.5	43.0	79.5	70.5	90.0	95.0	90.0	96.0	85.0	73.0	60.0	60.5	96.0
1908, . .	53.0	56.0	67.0	84.0	88.5	91.5	96.0	88.5	88.0	90.5	58.0	65.5	96.0
1909, . .	54.0	54.5	54.0	80.0	81.5	91.5	93 0	94.0	83.0	85.0	72.0	51.5	94.0
1910, . .	56 0	53.5	78.0	80.0	84.0	88.0	97.0	85.5	82.0	84.0	61.0	47.0	97.0
1911, . .	50.5	51.5	59.0	86.0	94.5	89.5	104.0	94.5	84.0	72.5	66.5	62.0	104.0
1912, . .	45.0	49.5	60.5	78.0	88.0	91.0	98.5	89.0	86.0	83.0	67.0	65.0	98.5
1913, . .	59.5	55.0	74.0	84.5	89.0	92.0	100.0	97.0	87.5	79.0	68.0	53.0	100.0
Mean,	51.2	51.1	62.2	79.4	87.0	91.3	93.7	90.7	86.9	79.0	64 2	54 7	95.6

Minimum Temperatures (in Degrees F.).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Minimum Annual.
1889, . .	8.0	—2.0	21.0	32.0	38.0	46.0	34.0	45.0	40.0	26.0	20.0	5.5	—2.0
1890, . .	4.5	3.0	—6.5	22.0	31.5	40.5	40.0	41.5	28.5	26.0	11.5	—5.0	—6.5
1891, . .	—0.4	—6.0	—1.0	18.0	25.0	34.0	41.5	45.0	36.0	20.0	3.5	9.0	—6.0
1892, . .	—9.5	—7.0	6.0	20.5	28.0	41.0	42.0	50.0	31.0	23.0	14.0	—1.0	—9.5
1893, . .	—13.0	—4.5	4.0	19.0	30.0	41.5	41.0	39.0	30.0	23.0	11.0	—12.0	—13.0
1894, . .	1.0	—17.0	17.0	16.0	29.0	37.5	48.0	37.0	35.0	32.0	10.0	—4.0	—17.0
1895, . .	—4.5	—10.0	5.0	25.0	29.5	44.0	46.0	38.0	33.0	20.0	15.0	—3.0	—10.0
1896, . .	—12.0	—14.0	5.0	21.0	32.0	39.0	50.0	42.0	31.0	23.0	15.0	—9.5	—14.0
1897, . .	0.0	—11.0	—1.5	20.5	31.5	38.0	55.0	42.0	32.0	20.5	5.0	—3.5	—11.0
1898, . .	—15.5	—19.0	14.5	17.0	32.5	39.5	40.0	44.5	34.5	27.0	6.0	—12.0	—19.0
1899, . .	—21.5	—10.0	10.0	21.0	33.0	42.0	43.0	41.0	32.5	20.5	17.5	2.0	—21.5
1900, . .	—4.5	—8.0	3.0	21.0	24.0	40.0	44.5	43.0	35.5	22.0	12.0	0.5	—8.0
1901, . .	—8.0	—4.5	—0.5	28.0	31.5	41.0	48.5	53.0	33.0	24.0	6.0	—10.5	—10.5
1902, . .	—0.5	5.0	16.5	25.5	30.0	40.0	45.0	43.0	35.0	22.5	17.5	—15.0	—15.0
1903, . .	—12.0	—11.0	19.0	22.0	24.5	38.0	44.5	42.5	30.5	22.5	6.0	—9.5	—12.0
1904, . .	—26.0	—8.0	—3.0	20.0	37.0	44.0	46.5	40.0	26.0	18.0	7.5	—3.5	—26.0
1905, . .	—13.0	—11.0	1.0	22.0	32.0	36.0	46.0	41.5	32.0	21.5	11.0	3.0	—13.0
1906, . .	3.5	—5.0	—7.5	21.0	31.5	37.0	45.0	47.5	31.5	24.0	18.5	—3.0	—7.5
1907, . .	—23.5	—18.5	5.5	20.5	25.0	38.0	44.0	41.0	36.0	20.5	19.5	10.0	—23.5
1908, . .	—5.5	—12.0	5.0	18.0	33.5	36.0	46.0	37.0	33.0	23.0	18.5	2.0	—12.0
1909, . .	—7.0	—3.0	13.0	19.0	32.5	40.0	42.0	38.0	35.0	24.0	18.5	—8.5	—8.5
1910, . .	—9.0	—7.0	12.5	24.0	31.0	35.0	48.5	41.0	34.0	19.0	15.0	—2.0	—9.0
1911, . .	1.5	—3.0	2.5	18.0	27.0	44.5	49.0	44.5	29.0	24.0	18.5	10.0	—3.0
1912, . .	—19.0	—16.5	1.0	24.0	32.5	36.0	41.0	39.0	35.0	26.5	18.5	3.0	—19.0
1913, . .	11.0	—4.5	1.0	22.5	30.5	37.0	41.0	41.0	31.0	24.5	23.0	5.0	—4.5
Mean, .	—7.0	—8.2	5.7	21.5	30.5	39.4	45.3	42.3	32.8	23.1	13.5	—2.9	—12.0

Mean Dew Point (in Degrees F.).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, . .	26.3	21.2	30.4	43.8	52.8	61.1	62.7	59.5	56.9	39.4	38.3	30.9	43.6
1890, . .	23.8	25.2	26.5	35.6	58.0	57.9	61.5	57.2	55.8	41.0	29.7	14.7	40.6
1891, . .	20.7	21.7	22.6	36.3	44.6	57.0	58.5	62.4	58.1	40.6	30.4	28.2	40.1
1892, . .	18.8	20.9	21.5	33.0	44.9	62.3	60.9	62.1	51.9	41.0	32.1	20.5	39.2
1893, . .	13.9	17.3	24.0	31.4	45.7	58.3	58.8	59.9	49.1	44.2	29.9	21.9	37.9
1894, . .	21.6	17.9	31.1	34.2	52.6	57.9	62.4	58.6	56.2	44.6	27.3	22.3	40.5
1895, . .	19.2	17.1	26.2	35.8	48.7	59.6	59.3	60.4	54.8	35.4	34.4	23.6	39.5
1896, . .	14.3	22.0	25.6	35.9	48.3	53.9	62.4	61.7	54.5	42.4	37.7	19.6	39.9
1897, . .	18.0	18.1	26.9	35.7	48.0	53.3	64.6	59.7	52.7	39.0	31.8	24.2	39.6
1898, . .	18.4	21.8	30.5	34.2	48.8	59.3	64.6	64.6	56.9	46.6	32.7	20.8	41.6
1899, . .	16.6	17.0	25.5	36.5	48.6	59.5	62.5	59.4	51.5	48.8	29.8	25.1	40.1
1900, . .	18.1	17.8	19.3	34.9	43.7	57.0	62.3	62.0	54.7	47.1	32.0	21.7	39.2
1901, . .	16.6	10.6	24.7	35.6	45.7	56.2	63.4	62.3	54.5	39.9	24.1	17.9	37.6
1902, . .	12.3	15.1	32.2	36.3	44.0	53.5	57.3	57.8	53.7	40.5	34.2	15.0	37.7
1903, . .	16.0	21.0	34.6	34.1	44.9	53.7	59.3	54.7	52.5	39.2	25.6	16.1	37.6
1904, . .	9.3	9.5	22.4	31.5	48.4	56.6	61.5	59.0	52.7	37.5	25.1	12.6	35.5
1905, . .	12.8	9.2	24.8	33.5	45.7	56.5	63.2	59.0	52.4	40.3	26.8	23.8	37.3
1906, . .	20.8	15.2	19.3	34.7	46.4	58.3	63.1	63.6	55.2	42.9	27.7	16.5	38.6
1907, . .	13.4	9.0	25.8	32.0	42.2	55.0	61.0	56.5	54.6	37.1	32.0	23.7	36.9
1908, . .	16.5	14.7	26.9	31.9	50.1	56.2	63.7	58.3	53.5	41.8	30.1	18.6	38.5
1909, . .	19.0	21.0	26.0	35.5	45.1	56.6	58.6	57.8	52.6	38.0	32.6	15.8	38.2
1910, . .	18.2	16.9	28.8	39.2	45.5	55.2	61.0	57.4	53.5	41.2	28.2	14.2	38.3
1911, . .	19.7	15.3	22.2	30.1	51.7	55.8	61.7	59.0	52.9	40.1	27.4	23.9	38.3
1912, . .	7.8	12.6	23.4	37.0	50.2	54.5	60.5	58.1	54.3	41.7	31.6	23.5	38.6
1913, . .	25.9	14.1	30.7	38.5	46.0	54.6	59.8	58.6	51.0	46.5	32.1	23.5	40.1
Mean, .	17.5	16.9	26.1	35.1	47.6	56.8	61.4	60.0	53.9	41.5	30.5	20.7	39.0

Mean Relative Humidity.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, . .	79.0	90.0	75.0	78.3	73.8	79.1	78.2	80.4	83.3	75.7	75.4	75.2	78.6
1890, . .	68.2	74.8	77.3	64.7	67.1	71.3	70.1	74.9	80.9	68.2	67.8	67.2	71.1
1891, . .	72.2	69.4	63.7	60.1	59.3	65.3	66.1	70.3	72.1	65.5	68.7	68.7	66.8
1892, . .	73.7	72.8	64.1	54.5	60.3	68.9	65.6	74.9	70.7	65.5	71.0	70.3	67.7
1893, . .	80.2	74.7	71.4	64.8	66.0	71.1	64.8	70.7	72.8	67.0	68.8	80.9	71.1
1894, . .	78.8	77.5	67.5	60.5	65.8	68.1	68.2	69.9	74.4	82.7	70.8	79.0	71.9
1895, . .	82.5	83.9	80.6	68.1	65.0	68.5	72.7	72.7	73.7	69.2	80.5	75.4	74.4
1896, . .	73.3	87.5	85.3	62.0	62.5	67.3	73.1	79.9	84.0	85.0	82.3	79.8	76.9
1897, . .	77.1	75.7	78.9	68.2	71.5	73.3	80.1	79.6	76.6	68.7	83.2	83.9	76.4
1898, . .	85.2	83.1	72.6	72.1	78.4	77.1	79.3	82.1	80.0	83.6	83.4	80.2	79.8
1899, . .	77.7	82.5	79.1	69.2	70.3	74.0	75.2	74.1	74.0	75.9	76.2	79.4	75.6
1900, . .	75.1	77.4	67.8	64.7	65.5	69.5	71.1	75.9	73.1	77.0	75.9	74.9	72.3
1901, . .	74.3	68.5	70.8	68.1	68.1	65.5	72.3	76.3	76.8	70.5	71.1	69.8	71.0
1902, . .	66.2	66.8	72.3	67.1	63.4	70.8	77.2	76.3	79.1	70.9	75.6	72.5	71.6
1903, . .	72.0	77.7	76.4	64.7	61.3	81.1	71.4	78.2	75.0	74.5	73.5	76.5	73.5
1904, . .	85.5	77.7	74.4	70.8	69.7	77.0	77.7	80.5	81.8	74.0	77.5	77.8	77.0
1905, . .	77.2	75.1	76.7	66.7	68.2	78.8	79.1	82.5	83.2	75.9	73.5	80.6	76.5
1906, . .	74.8	77.4	73.9	70.3	70.9	79.1	82.4	82.9	80.1	84.1	72.2	77.0	77.1
1907, . .	76.1	80.2	73.4	74.1	75.3	76.9	76.4	74.9	83.0	77.7	85.9	80.4	77.9
1908, . .	73.8	84.8	77.9	64.3	74.8	66.2	76.6	79.0	79.1	79.0	79.6	75.1	75.8
1909, . .	78.5	78.9	81.3	76.3	71.2	73.6	71.8	78.1	83.1	76.1	77.2	75.2	76.8
1910, . .	80.9	81.3	72.8	69.1	71.6	75.4	70.3	76.3	82.7	75.0	78.7	78.4	76.0
1911, . .	78.8	77.6	73.2	65.2	72.2	74.5	70.7	77.5	82.4	79.0	73.5	77.3	75.2
1912, . .	81.3	78.4	80.3	77.2	78.5	70.0	71.5	78.3	84.0	74.9	77.2	75.4	77.3
1913, . .	79.0	74.5	79.3	74 4	73.0	68.4	70.5	74.2	80.2	79.2	74.0	81.2	75.7
Mean, .	76.9	77.9	74.6	67.8	68.9	72.4	73.3	76.8	78.6	75.0	75.7	76.5	74.6

Mean Per Cent. of Cloudiness from Tri-daily or Semi-daily Observations.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, . .	55	40	63	55	42	53	54	43	65	60	68	61	55
1890, . .	52	66	66	50	59	50	56	57	59	64	47	53	57
1891, . .	61	59	55	49	54	47	54	58	50	54	50	51	53
1892, . .	63	55	45	42	66	50	35	53	29	46	58	45	49
1893, . .	52	57	46	55	55	58	44	45	46	40	49	54	50
1894, . .	53	53	55	53	52	54	50	44	53	44	50	44	50
1895, . .	51	39	55	54	46	48	58	44	42	42	61	45	49
1896, . .	43	63	54	39	40	47	50	40	52	63	59	42	49
1897, . .	46	51	56	46	47	47	64	42	39	39	71	68	51
1898, . .	66	64	53	68	65	57	53	60	48	62	60	66	60
1899, . .	53	58	66	42	54	54	50	57	47	60	53	52	54
1900, . .	52	62	47	46	54	49	48	49	54	64	72	62	55
1901, . .	58	45	68	75	70	48	63	67	51	48	65	65	60
1902, . .	60	63	66	68	58	62	66	50	57	51	62	60	60
1903, . .	61	53	63	50	36	71	52	63	42	58	41	49	53
1904, . .	55	42	57	52	45	59	55	47	54	42	43	57	51
1905, . .	58	31	46	43	56	61	55	56	48	36	42	56	49
1906, . .	51	44	49	49	47	54	53	50	32	52	53	66	50
1907, . .	58	41	44	33	68	50	42	36	64	30	48	51	49
1908, . .	37	42	48	42	50	28	47	45	27	37	46	49	41
1909, . .	61	60	49	52	56	44	33	35	55	49	56	45	50
1910, . .	60	57	49	56	66	59	34	47	55	44	68	55	54
1911, . .	62	55	49	42	55	54	42	61	53	59	60	63	55
1912, . .	55	36	53	64	64	43	46	50	60	40	51	58	52
1913, . .	63	42	62	55	53	35	39	41	47	63	53	45	50
Mean, .	55.4	51.1	54.6	51.2	54.3	51.3	49.7	49.6	49.2	49.9	55.4	54.5	52.2

Hours of Bright Sunshine by Sun Thermometer.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Possible hours,	294	296	371	402	453	457	462	429	373	341	293	283	4,454
1889, . .	134	183	138	191	270	277	182	194	120	129	84	108	2,010
1890, . .	112	131	160	245	225	264	289	199	166	129	143	131	2,194
1891, . .	126	124	195	240	226	248	222	204	224	150	141	143	2,245
1892, . .	128	138	196	244	183	218	287	201	234	178	101	144	2,261
1893, . .	130	111	172	166	188	209	259	225	185	182	133	112	2,072
1894, . .	120	121	150	174	208	180	237	237	176	160	128	159	2,051
1895, . .	153	187	172	188	243	246	192	251	254	197	111	169	2,363
1896, . .	157	168	210	258	297	263	260	254	189	115	105	172	2,448
1897, . .	144	154	188	239	236	248	214	274	221	209	90	108	2,325
1898, . .	132	138	200	168	200	270	236	201	218	157	126	113	2,159
1899, . .	151	147	134	280	221	235	259	206	200	140	130	142	2,245
1900, . .	167	120	216	227	235	259	260	226	177	136	86	108	2,216
1901, . .	117	172	93	103	159	254	208	160	215	178	100	107	1,866
1902, . .	120	138	143	139	210	179	185	209	149	164	109	119	1,864
1903, . .	114	145	138	199	311	102	247	169	236	154	182	129	2,126
1904, . .	144	173	172	182	256	256	274	292	204	183	148	115	2,401
1905, . .	119	178	216	247	286	247	263	242	186	209	156	128	2,477
1906, . .	128	183	225	269	288	316	278	266	254	189	155	111	2,660
1907, . .	130	200	245	268	209	217	297	217	110	177	125	122	2,317
1908, . .	154	200	220	277	282	362	308	268	242	186	111	133	2,743
1909, . .	127	157	232	220	263	300	290	241	192	194	146	148	2,510
1910, . .	119	180	275	286	287	279	371	229	245	229	137	156	2,793
1911, . .	145	132	236	296	320	280	297	227	195	124	74	105	2,431
1912, . .	149	180	224	198	214	314	260	238	156	163	146	148	2,390
1913, . .	179	205	182	211	221	312	324	282	182	91	113	121	2,423
Mean, .	137	159	189	221	224	253	260	228	197	165	122	130	2,304
Mean per cent., .	46.6	53.4	50.9	55.0	49.5	55.4	56.3	53.3	52.9	48.4	41.6	45.9	51.7

Precipitation (in Inches).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, . .	3.29	1.45	1.46	2.42	4.71	5.01	10.52	2.72	3.17	4.58	6.04	3.57	48.94
1890, . .	2.61	4.20	5.37	1.73	5.39	1.53	5.63	4.88	5.85	7.13	1.32	2.86	48.50
1891, . .	6.75	4.23	2.99	2.66	1.97	4.75	5.28	4.18	2.66	2.94	2.99	5.40	46.80
1892, . .	5.85	1.90	2.40	0.76	6.28	3.46	4.41	6.47	2.16	0.66	4.98	1.01	40.34
1893, . .	3.33	5.75	3.66	4.41	5.02	3.32	2.59	3.49	2.82	4.88	2.81	4.86	46.94
1894, . .	2.16	1.74	1.77	1.83	4.00	3.13	1.55	0.31	4.63	4.85	3.14	3.53	32.64
1895, . .	3.87	1.05	2.71	5.56	2.07	2.76	3.87	3.46	5.04	4.77	5.36	3.94	44.46
1896, . .	1.07	4.67	6.11	1.32	2.58	2.57	4.96	3.84	5.41	3.23	3.03	0.87	39.66
1897, . .	3.00	2.52	3.53	2.42	4.38	6.65	14.51	4.29	1.94	0.73	5.85	7.23	57.05
1898, . .	7.15	3.80	1.63	3.73	5.61	3.69	4.09	6.85	3.65	6.27	5.48	2.30	54.25
1899, . .	2.80	3.56	7.13	1.79	1.28	4.13	4.89	2.00	7.90	1.84	2.17	2.00	41.49
1900, . .	4.08	8.12	5.76	1.85	3.78	3.65	4.67	4.11	3.67	3.72	5.87	2.40	51.68
1901, . .	1.81	0.62	5.66	5.95	6.91	0.87	3.86	6.14	4.17	3.88	2.08	7.77	49.72
1902, . .	1.72	3.54	5.29	3.31	2.32	4.54	4.66	4.65	5.83	5.59	1.27	4.27	46.99
1903, . .	3.28	4.27	6.40	2.30	0.48	7.79	4.64	4.92	1.66	2.72	2.04	3.95	44.45
1904, . .	4.74	2.45	4.48	5.73	4.55	5.35	2.62	4.09	5.45	1.74	1.35	2.75	45.30
1905, . .	3.90	1.70	3.66	2.56	1.28	2.86	2.63	6.47	6.26	2.27	2.06	3.15	38.80
1906, . .	2.18	2.73	4.90	3.25	4.95	2.82	3.45	6.42	2.59	5.69	1.98	4.49	45.45
1907, . .	2.73	1.92	1.82	1.98	4.02	2.36	3.87	1.44	8.74	5.00	4.50	3.89	42.27
1908, . .	2.25	3.53	2.86	1.97	4.35	0.76	3.28	4.27	1.73	1.57	1.06	3.05	30.68
1909, . .	3.56	5.16	3.01	5.53	3.36	2.24	2.24	3.79	4.99	1.23	1.06	2.95	39.12
1910, . .	6.14	5.08	1.37	3.07	2.67	2.65	1.90	4.03	2.86	0.93	3.69	1.72	36.11
1911, . .	2.36	2.18	3.80	1.87	1.37	2.02	4.21	5.92	3.41	8.81	3.84	4.42	44.21
1912, . .	2.18	3.16	5.70	3.92	4.34	0.77	2.61	3.22	2.52	2.07	4.03	4.04	38.56
1913, . .	3.98	2.94	6.38	3.30	4.94	0.90	1.59	2.26	2.56	5.16	2.11	3.38	39.50
Mean, .	3.47	3.28	3.99	3.01	3.74	3.22	4.34	4 17	4.07	3.69	3.20	3.59	43.76

Wind Movement (in Miles).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, .	5,101	4,828	7,068	5,648	4,056	4,056	4,032	2,811	4,310	4,762	2,589	4,445	53,706
1890, .	4,914	4,616	5,395	5,032	5,284	3,776	3,976	4,116	3,507	4,143	4,228	5,673	54,648
1891, .	4,954	4,759	6,261	5,484	4,610	3,713	3,907	3,324	3,201	4,319	5,215	5,465	55,212
1892, .	5,059	3,438	7,046	5,370	5,056	4,500	3,365	3,390	3,672	4,071	5,231	4,522	54,720
1893, .	4,056	5,242	5,757	5,384	4,833	3,572	3,640	4,126	3,508	4,198	4,179	3,916	52,411
1894, .	4,193	4,865	4,406	4,105	2,180	1,838	1,109	1,920	1,414	2,540	4,179	3,508	36,257
1895, .	2,896	3,920	4,360	4,098	4,071	3,050	2,934	3,397	3,444	4,029	4,156	5,506	46,861
1896, .	4,943	6,445	8,182	4,674	4,838	3,926	4,048	2,968	4,686	4,544	4,654	5,290	59,198
1897, .	5,501	4,493	5,363	5,523	5,603	4,208	4,007	3,452	3,506	3,938	4,558	4,068	54,220
1898, .	3,494	3,699	3,864	5,477	4,769	4,162	3,377	3,111	2,787	3,999	4,856	4,830	48,425
1899, .	4,926	4,427	5,275	3,984	4,219	3,814	3,891	2,522	3,967	2,582	3,361	4,142	47,110
1900, .	4,904	5,016	5,602	5,039	4,381	4,101	3,701	2,322	3,042	3,315	4,877	4,203	50,503
1901, .	5,224	5,484	5,482	6,211	4,525	3,647	2,763	2,144	2,358	3,652	4,583	4,280	50,353
1902, .	4,078	5,199	6,601	4,642	4,328	4,102	2,929	2,386	2,680	4,398	3,077	4,018	48,438
1903, .	4,254	4,529	4,169	5,125	3,908	3,130	3,087	2,105	2,890	4,703	3,362	4,994	46,256
1904, .	4,112	4,910	4,444	4,902	3,830	3,127	3,268	3,232	3,602	4,160	3,470	3,940	46,994
1905, .	5,180	4,503	3,006	4,855	5,004	3,108	3,464	3,030	2,527	3,397	4,317	4,051	46,442
1906, .	5,706	4,565	5,686	4,777	3,766	1,409	3,773	3,412	4,249	4,398	5,978	5,554	53,273
1907, .	4,987	5,272	5,718	7,096	5,946	4,223	4,114	3,928	3,582	5,111	4,773	5,266	60,016
1908, .	7,770	5,511	5,759	8,208	5,818	4,571	3,815	3,802	3,757	3,643	5,485	5,432	63,571
1909, .	5,991	5,585	7,034	6,679	5,371	4,225	5,097	3,485	4,008	4,400	5,793	5,845	63,513
1910, .	5,786	5,834	5,579	5,533	5,289	3,685	3,812	4,271	3,336	5,467	5,215	5,435	59,242
1911, .	6,085	5,515	7,485	5,738	4,939	3,546	3,878	3,029	3,809	3,451	5,950	4,857	58,282
1912, .	4,872	4,798	5,291	6,094	5,332	4,533	3,992	3,698	2,980	3,953	5,037	5,337	55,897
1913, .	5,359	5,194	6,413	5,659	3,672	3,746	4,315	3,441	3,220	4,698	5,003	4,400	55,120
Mean, .	4,974	4,906	5,650	5,413	4,625	3,671	3,612	3,177	3,362	4,115	4,565	4,759	52,827

Maximum Wind Pressure (in Pounds per Square Foot).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Maximum Annual.
1889, . .	26.0	24.0	16.7	15.5	9.0	11.5	10.0	6.5	9.7	12.2	14.5	29.0	29.0
1890, . .	27.7	17.5	13.5	11.5	16.5	10.0	9.2	13.0	5.0	11.0	9.5	24.5	27.7
1891, . .	16.2	13.5	10.5	14.0	10.7	10.5	4.5	2.5	4.0	9.5	15.7	14.0	16.2
1892, . .	10.5	11.5	20.5	16.7	15.7	20.5	11.5	7.5	15.5	12.5	16.0	13.5	20.5
1893, . .	12.0	20.0	18.5	24.5	24.7	9.0	13.0	37.5	14.5	23.0	14.0	18.5	37.5
1894, . .	20.0	22.5	11.5	15.5	14.5	14.0	9.5	9.5	13.0	10.0	18.0	15.0	22.5
1895, . .	13.0	25.0	20.0	10.0	7.0	8.0	8.0	5.5	43.0	14.0	22.0	24.0	43.0
1896, . .	15.0	24.5	19.0	18.0	25.0	7.7	8.5	12.5	19.0	12.0	15.0	12.0	25.0
1897, . .	18.5	10.0	13.5	14.0	22.0	7.0	12.0	14.0	20.0	11.5	20.0	12.0	22.0
1898, . .	22.5	15.5	15.5	10.0	18.0	8.5	17.5	13.0	30.5	12.0	19.0	28.0	30.5
1899, . .	20.0	15.0	22.0	9.5	10.5	7.5	12.0	5.5	6.5	6.5	11.0	15.5	22.0
1900, . .	20.5	30.5	16.0	13.0	22.0	12.5	23.0	16.0	17.0	10.0	18.0	13.0	30.5
1901, . .	12.5	10.5	10.5	13.5	11.5	7.5	14.5	2.0	24.0	9.0	17.5	14.5	24.0
1902, . .	12.0	24.0	24.0	14.0	10.0	15.0	7.5	8.0	4.0	8.0	9.5	12.5	24.0
1903, . .	12.5	22.0	8.0	12.5	9.5	9.0	15.5	3.0	7.5	3.0	9.5	17.0	22.0
1904, . .	11.0	23.5	14.5	15.5	11.0	6.0	11.0	6.5	14.5	23.5	11.5	9.5	23.5
1905, . .	23.5	18.0	16.5	18.0	9.5	6.0	9.0	7.0	7.0	9.0	9.0	14.0	23.5
1906, . .	8.0	8.5	7.0	10.0	7.5	5.0	6.5	4.5	4.5	9.0	8.5	12.0	12.0
1907, . .	14.0	20.0	27.0	12.0	6.5	6.0	32.5	4.5	6.0	9.0	8.5	18.5	32.5
1908, . .	16.0	23.0	10.0	32.0	13.0	7.0	10.0	4.0	9.0	9.0	9.5	7.5	32.0
1909, . .	8.5	18.5	18.0	27.5	8.0	7.0	7.0	3.0	5.5	8.5	13.0	14.0	27.5
1910, . .	15.0	15.0	11.5	6.0	7.5	4.0	6.0	8.5	2.5	8.0	7.5	10.5	15.0
1911, . .	19.0	9.5	21.0	9.0	7.5	5.0	7.5	3.0	5.0	6.0	15.0	30.5	30.5
1912, . .	19.5	23.0	6.0	10.0	13.5	8.5	5.5	6.5	3.5	5.0	18.0	10.0	23.0
1913, . .	18.0	13.5	23.5	16.5	5.5	4.5	27.0	4.5	6.5	23.0	14.5	7.0	27.0
Maximum,	27.7	30.5	27.0	32.0	25.0	20.5	32.5	37.5	43.0	23.5	22.0	30.5	43.0

Maximum Velocity of Wind (in Miles per Hour).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Maximum Annual.
1889, . .	72	69	58	56	42	48	45	36	44	50	54	76	76
1890, . .	74	59	52	48	57	45	43	51	32	47	44	70	74
1891, . .	57	52	46	53	46	46	30	23	28	44	56	53	57
1892, . .	46	48	64	58	56	64	48	39	56	50	57	52	64
1893, . .	49	63	61	70	70	42	51	87	54	68	53	61	87
1894, . .	63	67	48	56	54	53	44	44	51	45	60	55	67
1895, . .	51	71	63	45	37	40	40	33	93	53	66	69	93
1896, . .	55	70	62	60	71	39	41	50	62	49	55	49	71
1897, . .	61	45	52	53	66	37	49	53	63	48	63	49	66
1898, . .	67	56	56	45	60	41	59	51	78	49	62	75	78
1899, . .	64	55	66	44	46	39	49	33	36	36	47	56	66
1900, . .	64	78	57	51	66	50	68	57	60	45	60	51	78
1901, . .	49	46	46	52	48	39	54	20	69	42	59	54	69
1902, . .	49	69	69	53	45	55	39	40	28	40	44	50	69
1903, . .	50	66	40	50	44	43	56	24	39	40	44	58	66
1904, . .	47	69	54	56	47	35	47	36	54	69	48	44	69
1905, . .	69	60	57	60	44	35	43	37	37	43	43	53	69
1906, . .	45	41	37	45	39	32	36	30	30	42	41	49	49
1907, . .	53	63	74	49	36	35	81	30	35	42	41	61	81
1908, . .	56	68	45	80	51	37	45	28	42	42	44	39	80
1909, . .	41	61	60	74	40	37	37	24	33	41	51	53	74
1910, . .	55	55	48	35	39	28	35	41	22	40	39	46	55
1911, . .	62	44	65	42	39	32	39	24	32	35	55	79	79
1912, . .	62	68	35	45	52	41	33	36	26	32	60	45	68
1913, . .	60	52	68	58	33	30	73	30	36	68	54	37	73

Snow, Frost and Weather.

Year.	Last Snow.	First Snow.	Total Snowfall (Inches).	Last Frost.	First Frost.	Number of Days of Precipitation.	Number of Clear Days.	Number of Fair Days.	Number of Cloudy Days.
1889, . .	April 2	Oct. 13	26.0	May 26	Sept. 21	119	94	110	161
1890, . .	April 8	Oct. 19	43.5	May 12	Sept. 25	141	137	105	123
1891, . .	May 5	Nov. 26	54.2	May 19	Oct. 12	112	145	103	117
1892, . .	April 10	Nov. 5	42.5	May 10	Sept. 30	108	123	109	134
1893, . .	April 21	Nov. 4	74.3	May 8	Sept. 3	143	101	96	168
1894, . .	April 12	Nov. 5	71.5	May 22	Aug. 22	125	107	83	175
1895, . .	April 3	Oct. 20	61.0	May 17	Aug. 22	119	118	110	137
1896, . .	April 7	Nov. 14	44.0	May 1	Sept. 24	108	132	192	132
1897, . .	April 27	Nov. 12	52.8	May 8	Sept. 22	127	108	109	148
1898, . .	April 6	Nov. 24	69.5	April 27	Sept. 21	125	78	138	149
1899, . .	April 16	Oct. 12	52.0	May 4	Sept. 14	110	91	139	135
1900, . .	April 9	Nov. 9	37.0	May 29	Sept. 15	131	83	144	138
1901, . .	April 3	Nov. 11	52.3	May 6	Sept. 26	135	81	105	179
1902, . .	April 2	Oct. 29	57.0	May 14	Sept. 6	144	73	113	179
1903, . .	April 4	Oct. 26	33.5	May 2	Sept. 25	116	119	98	148
1904, . .	April 20	Oct. 12	59.5	April 23	Sept. 22	126	142	96	128
1905, . .	May 1	Nov. 9	40.0	May 24	Sept. 12	122	130	128	107
1906, . .	April 23	Nov. 11	56.2	May 20	Sept. 25	121	130	140	95
1907, . .	May 11	Nov. 23	54.5	May 22	Sept. 27	122	95	155	115
1908, . .	April 20	Nov. 5	38.5	June 3	Sept. 16	109	143	130	93
1909, . .	April 9	Nov. 5	31.0	May 12	Oct. 13	128	112	151	102
1910, . .	Mar. 14	Nov. 8	44.5	May 6	Sept. 23	117	142	152	71
1911, . .	April 19	Nov. 14	35.0	May 5	Sept. 14	120	106	131	128
1912, . .	April 9	Nov. 3	33.8	May 1	Aug. 31	117	71	182	113
1913, . .	April 9	Oct. 31	26.5	May 15	Sept. 10	135	105	144	116

Summary for the Twenty-five Years 1889–1913, inclusive.

Barometer (Pressure in Inches).

Maximum reduced to freezing, Feb. 26, 1889, 11 A.M.,	30.650
Minimum reduced to freezing, Feb. 8, 1895, 7 A.M.,	28.240
Maximum reduced to freezing and sea level, Feb. 26, 1889, 11 A.M.,	30.970
Minimum reduced to freezing and sea level, Jan. 3, 1913, 7 A.M.,	28.550
Mean,	30.012
Total range,	2.420
Greatest annual range, 1913,	2.330
Least annual range, 1905,	1.640
Mean annual range,	1.890
Greatest monthly range, January, 1913,	2.180
Least monthly range, August, 1894,	.440
Mean monthly range,	1.100

Air Temperature (in Degrees F.).

Highest, July 4, 1911, 3.30 P.M.,	104.0
Lowest, Jan. 5, 1904, 7.30 A.M.,	−26.0
Mean,	47.5
Total range,	130.0
Greatest annual range, 1904,	120.5
Least annual range, 1906,	98.5
Mean annual range,	107.6
Greatest monthly range, January, 1907,	78.0
Least monthly range, August, 1901,	33.5
Mean monthly range,	54.6
Greatest daily range, Dec. 10, 1902,	54.0
Least daily range, June 2, 1907,	2.0

Humidity.

Mean dew point,	39.0
Mean relative humidity,	74.6

Precipitation (in Inches).

Total rain or melted snow,	1,093.91
Total snowfall,	1,190.70
Greatest annual precipitation, 1897,	57.05
Least annual precipitation, 1908,	30.68
Mean annual precipitation,	43.76
Greatest monthly precipitation, July, 1897,	14.51
Least monthly precipitation, August, 1894,	.31
Mean monthly precipitation,	3.65

Wind (in Miles).

Total movement,	1,320,668
Greatest annual movement, 1908,	63,571
Least annual movement, 1894,	36,257
Mean annual movement,	52,827
Greatest monthly movement, April, 1908,	8,208
Least monthly movement, July, 1894,	1,109
Mean monthly movement,	4,402
Greatest daily movement, April 8, 1909,	705
Least daily movement, Sept. 29, 1894, March 7, 1890, Jan. 6, 1904,	0
Mean daily movement,	145
Maximum pressure per square foot, 43 pounds, = 93 miles per hour, Sept. 11, 1895, 3 P.M.	

Weather.

Mean cloudiness observed, per cent.,	52.2
Total cloudiness by the sun thermometer, per cent.,	48.3
Number of clear days,	2,766
Number of fair days,	3,073
Number of cloudy days,	3,291

Gales of 75 or more miles per hour: 1889, Dec. 26, 76, N.W.; 1893, Aug. 29, 87, S.W.; 1895, Sept. 11, 93, N.E.; 1898, Sept. 7, 78, S.W.; Dec. 4, 75, E.S.E.; 1900, Feb. 22, 78, W.N.W.; 1907, July 20, 81, W.; 1908, April 11, 80, N.N.W.; 1911, Dec. 28, 79, W.N.W.

The following summary was abstracted from meteorological records taken in Amherst prior to the establishment of the meteorological observatory at the college in 1889.

The records from 1836 to 1883 are from the observations of the late Prof. E. S. Snell of Amherst College. These records were taken at his house, about one and a half miles south of the location of the meteorological observatory at the Massachusetts Agricultural College, and at practically the same elevation above sea level.

The precipitation records are believed to be fairly comparable with the records of this station, although perhaps slightly affected by the difference of topography surrounding the two places. As Professor Snell changed his time of taking temperatures, and used different methods of deducing the mean temperatures in conformity with the current practices at different dates, the comparison with those of this station should be made with more caution. The maximum and minimum temperatures of the earlier years were not all taken with self-registering instruments, and this fact should be taken into consideration when comparisons are made.

The records from 1883 to 1889 were taken at the State Experiment Station, on the college grounds, under the direction of Dr. C. A. Goessmann, at that time the director of the State Agricultural Experiment Station, and are fairly comparable with the records of this station.

Mean temperature for seventy-seven years: —

$$\frac{47.5 \times 25 + 46.7 \times 52}{77} = 46.9 \text{ degrees.}$$

Mean precipitation for seventy-eight years: —

$$\frac{44.36 \times 53 + 43.76 \times 25}{78} = 44.17 \text{ inches.}$$

Record of the Rainfall in Inches from 1836 to 1888, inclusive.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1836, . .	4.21	3.83	3.13	1.98	2.59	3.45	6.02	0.96	2.28	3.02	3.49	5.80	40.76
1837, . .	1.75	2.42	2.65	4.33	5.76	4.49	7.35	2.57	1.07	2.06	1.90	2.35	38.70
1838, . .	2.45	1.67	1.69	2.02	3.63	4.90	2.27	3.95	6.38	4.12	5.77	0.96	39.81
1839, . .	1.66	1.75	1.69	4.14	3.49	3.30	9.56	2.51	2.82	1.78	3.04	7.09	42.83
1840, . .	3.15	2.03	3.18	3.98	1.91	4.60	3.34	6.82	5.20	5.04	4.61	3.15	47.01
1841, . .	5.80	1.50	2.85	4.52	3.47	1.65	2.55	3.18	3.50	3.73	2.80	6.08	41.63
1842, . .	1.02	3.78	2.39	2.92	2.40	3.18	1.95	7.42	3.23	2.84	3.73	3.19	38.05
1843, . .	1.99	3.49	5.73	4.82	2.09	5.18	2.53	9.38	1.57	9.45	3.07	2.28	51.58
1844, . .	3.44	2.18	4 12	0.57	5.59	3.00	3.81	4.93	1.84	6.49	2.12	2.49	40.58
1845, . .	4.97	3.37	3.56	1.70	2.42	2.57	3.31	2.79	2.58	4.66	3.90	3.91	39.74
1846, . .	2.74	2.55	4.35	1.54	4.33	3.10	3.25	2.44	0.47	2.09	4.96	3.10	34.92
1847, . .	4.86	4.88	3.57	1.41	1.91	4.44	4.48	4.06	3.63	3.99	4.17	6.41	47.81
1848, . .	2.92	2.60	3.03	1.55	6.18	2.58	4.72	1.53	2.49	3.15	3.09	5.54	39.38
1849, . .	0.99	0.99	4.21	2.24	3.61	1.53	2.25	7.86	1.40	6.36	3.65	3.36	38.45
1850, . .	4.75	3.56	1.86	3.93	8.72	2.88	6.81	6.50	4.93	3.65	2.63	5.37	55.59
1851, . .	1.66	5.07	1.28	4.43	4.07	3.69	4.31	3.03	2.05	5.43	5.30	3.17	43.50
1852, . .	2.42	3.35	3.26	4.71	2.30	2.54	3.38	5.19	2.48	1.76	6.43	4.88	42.70
1853, . .	2.11	6.69	2.39	3.79	5.40	2.64	3.59	7.13	5.66	3.75	6.24	1.84	51.23
1854, . .	2.01	4.53	3.11	8.33	3.19	1.75	3.53	0.99	5.46	2.31	7.48	2.39	45.08
1855, . .	5.06	2.70	1.08	3.85	1.49	5.19	6.10	2.55	0.55	10.08	4.12	5.41	48.18
1856, . .	2.48	0.79	1.12	2.51	5.31	1.92	1.96	12.13	3.47	1.40	2.85	4.19	40.13
1857, . .	3.55	2.41	2.12	7.68	6.82	2.66	4.98	3.14	3.04	3.88	2.07	5.31	47.66
1858, . .	3.52	1.60	0.80	3.20	2.98	4.62	6.73	4.82	4.14	3.86	2.16	3.16	41.59
1859, . .	4.89	3.54	6.27	2.96	4.08	6.16	2.61	6.65	4.47	1.85	2.96	4.85	51.29
1860, . .	1.21	2.93	1.58	1.28	4.57	3.57	6.13	2.68	6.12	2.18	3.52	3.84	39.61
1861, . .	4.34	3.28	3.76	5.65	4.45	2.69	5.23	4.10	2.75	4.53	3.93	2.17	46.88
1862, . .	5.25	2.84	4.20	2.28	2.33	11.69	5.12	2.98	2.12	3.28	4.76	1.91	48.86
1863, . .	5.05	4.43	5.60	2.33	3.59	4.09	8.64	6.11	2.16	4.04	5.28	4.87	56.19
1864, . .	2.20	1.12	2.58	2.57	2.54	1.38	0.96	4.40	2.92	2.94	6.20	4.63	34.44
1865, . .	3.48	2.88	5.98	2.90	7.89	2.94	3.72	1.86	0.37	4.98	2.45	3.54	42.99
1866, . .	1.36	4.62	3.16	2.03	4.48	5.66	4.02	3.96	4.71	3.38	3.86	3.57	44.81
1867, . .	1.32	3.65	3.12	3.79	4.61	5.67	4.00	9.16	1.11	3.85	4.31	1.51	46.10
1868, . .	3.52	1.03	3.25	4.27	7.66	2.44	3.28	5.67	10.63	1.37	4.80	1.47	49.59
1869, . .	3.47	4.14	5.46	1.53	5.65	5.99	2.98	1.04	4.32	11.36	2.59	4.96	53.49
1870, . .	5.87	5.25	2.71	3.70	1.72	2.73	2.53	2.83	1.75	4.49	3.28	1.84	38.70
1871, . .	1.96	2.91	3.99	3.09	3.82	6.58	3.52	6.45	1.30	6.09	3.51	2.67	45.89
1872, . .	1.51	1.89	2.87	2.20	3.11	3.25	7.07	5.28	6.20	3.64	4.48	2.69	44.19
1873, . .	5.01	2.17	3.13	1.74	3.91	1.59	2.93	3.47	4.77	6.36	3.51	3.31	41.90
1874, . .	5.46	2.19	1.35	6.03	5.22	5.06	11.58	2.69	1.82	1.85	3.54	1.17	47.96
1875, . .	2.90	3.62	4.20	3.33	2.19	2.89	8.15	6.17	4.65	3.89	3.97	1.03	46.99
1876, . .	2.31	5.53	7.14	3.11	3.96	3.87	4.84	0.27	3.71	1.12	2.49	3.22	41.57
1877, . .	2.52	0.36	6.97	2.45	1.93	4.59	6.47	2.79	0.91	6.99	5.44	1.02	42.44
1878, . .	3.58	3.67	2.57	5.85	2.36	6.00	2.16	6.97	2.82	2.05	5.34	6.02	49.39
1879, . .	1.75	3.49	2.98	3.85	3.32	5.37	5.75	5.89	2.59	1.80	2.35	4.85	45.99
1880, . .	4.58	3.60	2.68	2.64	1.90	1.40	6.34	2.91	2.69	2.27	2.50	2.29	35.80
1881, . .	4.01	1.77	4.86	1.65	4.28	3.95	1.50	2.76	2.37	4.24	4.58	6.15	42.12
1882, . .	5.44	4.23	5.20	1.52	6.50	2.25	1.83	0.25	11.85	1.67	1.33	1.47	43.54
1883, . .	3.24	4.03	1.70	2.18	6.20	3.99	3.69	1.57	3.17	4.31	1.80	2.99	38.87
1884, . .	3.60	4.62	5.67	2.48	2.02	1.38	3.75	5.10	1.25	2.40	2.53	5.58	40.38
1885, . .	3.78	3.88	0.86	3.38	3.08	3.49	2.07	8.31	0.85	3.65	5.54	3.54	42.43
1886, . .	5.39	3.94	3.31	1.73	3.10	2.33	3.82	2.60	5.48	2.97	5.25	3.61	43.53
1887, . .	4.57	5.05	4.05	2.98	1.13	5.09	8.93	7.75	1.22	2.10	3.35	4.11	50.33
1888, . .	3.87	3.94	5.96	3.08	4.29	5.40	3.63	4.29	10.70	5.19	3.91	3.78	58.04
Mean, .	3.34	3.18	3.44	3.18	3.88	3.76	4.45	4.39	3.43	3.88	3.83	3.59	44.36

Record of the Mean Temperature from 1837 to 1888, inclusive.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1837, . .	20.3	26.7	33.7	47.4	57.9	68.2	70.6	68.6	61.4	50.0	40.2	27.6	47.7
1838, . .	32.0	19.6	36.4	40.7	54.3	68.6	71.9	68.2	62.7	46.5	34.1	23.5	46.5
1839, . .	24.6	29.8	37.5	52.2	60.7	65.4	74.4	70.7	63.5	53.3	36.6	28.9	49.8
1840, . .	14.4	28.5	35.0	49.0	57.1	65.5	70.6	70.3	57.2	47.4	37.0	23.6	46.3
1841, . .	25.6	20.2	31.9	41.6	54.4	68.4	69.5	69.8	61.2	42.8	35.3	29.5	45.8
1842, . .	25.6	30.5	37.7	46.5	52.7	64.1	71.5	69.0	57.4	47.4	35.1	24.2	46.8
1843, . .	29.7	16.5	24.5	44.6	56.0	65.3	68.8	69.8	61.7	45.0	34.0	28.0	45.3
1844, . .	13.9	22.1	35.5	52.0	57.8	65.6	68.2	68.0	59.6	47.6	35.7	27.3	46.0
1845, . .	24.5	24.9	36.9	45.6	56.2	66.7	72.1	71.5	58.3	49.6	41.5	21.5	47.4
1846, . .	24.8	20.1	36.3	50.1	58.3	65.0	70.7	69.6	65.5	47.6	43.0	25.3	48.0
1847, . .	25.5	24.7	29.2	43.3	57.5	64.7	72.4	69.3	59.3	46.0	43.2	34.2	47.4
1848, . .	29.0	23.7	32.6	43.3	59.5	67.6	69.4	70.6	57.4	47.3	33.5	30.6	47.0
1849, . .	20.0	18.5	35.6	43.5	53.4	66.9	72.1	68.8	60.0	47.0	44.1	28.4	46.5
1850, . .	25.9	28.4	32.4	42.9	53.4	67.3	72.1	67.1	59.4	48.2	40.0	23.4	46.7
1851, . .	23.8	27.9	35.5	46.2	55.6	69.6	69.2	66.2	60.9	51.0	34.5	20.2	46.2
1852, . .	19.6	25.2	30.9	39.4	56.0	65.4	70.0	65.2	58.4	49.3	36.4	32.8	45.7
1853, . .	24.3	26.7	33.8	44.0	56.7	67.0	68.7	67.8	59.5	46.8	39.1	26.3	46.7
1854, . .	22.8	22.0	31.6	43.5	59.5	66.7	74.1	68.8	61.5	51.5	40.3	22.3	47.0
1855, . .	27.3	19.8	31.5	43.8	56.6	65.0	70.9	65.5	60.8	49.7	38.8	28.2	46.5
1856, . .	15.2	19.0	25.9	46.4	53.6	68.6	72.9	66.2	60.8	48.7	37.5	23.2	44.8
1857, . .	13.5	31.4	31.1	41.0	55.2	63.6	70.9	67.2	59.9	48.9	39.5	31.5	46.1
1858, . .	28.8	20.6	31.3	44.4	54.1	66.1	69.8	67.9	50.9	51.4	33.9	25.7	45.4
1859, . .	22.9	25.6	36.7	43.4	59.2	62.8	67.7	66.4	57.1	45.7	41.1	23.0	46.0
1860, . .	26.5	24.8	37.2	44.0	57.3	65.2	66.4	68.0	56.8	48.8	42.7	23.9	46.8
1861, . .	20.4	29.2	32.5	45.5	53.4	65.5	69.5	65.7	59.9	51.5	37.8	29.0	46.7
1862, . .	22.3	22.1	32.2	43.6	58.1	63.4	68.0	68.1	61.1	51.0	39.6	27.6	46.4
1863, . .	29.1	26.3	26.1	45.5	55.4	59.0	70.9	70.1	57.4	49.9	41.1	25.3	46.3
1864, . .	24.4	28.5	34.4	43.5	60.4	65.7	71.5	70.8	57.8	46.4	38.0	38.2	48.3
1865, . .	18.7	25.0	37.1	49.0	57.1	69.3	69.1	68.6	65.6	46.0	39.9	28.9	47.8
1866, . .	21.9	26.2	31.6	48.6	54.6	65.8	72.9	63.5	60.0	49.5	40.1	26.3	46.7
1867, . .	18.3	31.2	30.8	45.5	54.0	67.1	68.1	68.6	60.0	49.9	37.9	22.6	46.2
1868, . .	20.2	18.2	33.8	42.0	55.1	66.2	74.0	69.0	59.5	45.3	36.5	22.8	45.2
1869, . .	28.0	28.0	27.3	46.4	55.9	64.7	69.1	66.9	62.1	46.7	35.9	27.5	46.5
1870, . .	30.8	25.3	30.9	48.3	58.3	70.4	73.6	71.1	62.3	52.0	39.1	28.0	49.2
1871, . .	23.3	26.0	40.5	48.0	57.8	65.4	69.2	68.9	52.8	51.0	34.0	24.6	46.8
1872, . .	25.1	24.2	25.3	45.0	59.1	68.1	72.6	71.6	61.7	48.2	36.4	19.5	46.4
1873, . .	20.6	24.0	30.6	43.2	54.6	67.5	71.3	67.0	60.4	49.9	29.7	29.2	45.7
1874, . .	28.2	24.5	32.9	38.3	56.5	66.2	67.2	65.6	62.0	47.6	36.2	29.2	46.2
1875, . .	16.7	17.5	27.8	40.8	57.1	65.8	69.3	68.9	57.3	47.9	33.1	28.3	44.2
1876, . .	29.8	26.4	31.6	43.6	57.5	70.6	74.2	70.5	59.1	45.5	40.5	19.7	47.4
1877, . .	20.0	30.8	33.3	47.8	58.5	67.8	71.1	71.4	63.3	50.5	41.9	33.1	49.1
1878, . .	25.3	27.1	39.2	52.2	57.4	64.7	73.3	68.6	63.2	54.4	39.1	29.0	49.5
1879, . .	21.6	22.4	33.0	43.2	60.6	66.3	71.0	67.2	59.0	56.0	37.4	30.8	47.4
1880, . .	31.6	29.1	33.5	47.5	64.2	68.5	71.8	67.5	63.2	47.3	34.9	22.8	48.5
1881, . .	17.9	24.9	36.2	43.6	61.7	62.8	70.6	70.5	67.4	52.5	40.3	36.0	48.7
1882, . .	23.6	28.2	35.1	44.3	52.9	66.8	71.9	70.9	63.2	52.7	36.4	26.6	47.7
1883, . .	21.0	25.0	27.3	44.3	58.6	69.7	70.4	66.4	59.4	46.8	40.4	27.0	46.4
1884, . .	21.6	30.9	32.9	46.7	57.4	69.0	68.6	69.2	64.4	50.3	38.4	30.0	48.3
1885, . .	22.7	15.2	23.3	45.3	54.8	63.8	70.4	66.0	58.3	49.1	39.8	29.6	44.9
1886, . .	21.8	35.1	33.5	50.4	57.3	63.2	68.8	66.3	59.5	48.9	38.3	23.0	46.2
1887, . .	19.4	24.2	26.4	41.6	60.9	65.7	73.7	64.9	55.9	47.0	36.5	26.6	45.2
1888, . .	13.8	22.0	26.8	40.4	54.7	65.8	67.2	67.4	57.1	43.1	38.9	30.4	44.0
Mean, .	23.0	24.7	32.4	45.1	56.9	66.1	70.7	68.3	60.1	48.7	38.0	27.0	46.7

Record of the Maximum Temperature from 1838 to 1888, inclusive.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1838, . .	55.0	42.0	58.0	67.0	80.0	90.0	92.0	88.0	85.0	77.0	57.0	43.0	92.0
1839, . .	50.0	50.0	65.0	72.0	80.0	84.0	86.0	85.0	80.0	70.0	56.0	53.0	86.0
1840, . .	38.0	56.0	64.0	79.0	88.0	88.0	94.0	90.0	77.0	72.0	55.0	44.0	94.0
1841, . .	50.0	44.0	60.0	67.0	81.0	90.0	94.0	88.0	84.0	64.0	68.0	44.0	94.0
1842, . .	37.0	55.0	68.0	82.0	78.0	84.0	90.0	82.0	84.0	70.0	60.0	43.0	90.0
1843, . .	50.0	37.0	42.0	70.0	82.0	86.0	91.0	84.0	87.0	69.0	57.0	40.0	91.0
1844, . .	39.0	49.0	56.0	83.0	84.0	86.0	86.0	84.0	83.0	70.0	54.0	45.0	86.0
1845, . .	46.0	55.0	71.0	77.0	88.0	90.0	94.0	89.0	81.0	74.0	65.0	38.0	94.0
1846, . .	45.0	40.0	59.0	76.0	83.0	87.0	93.0	90.0	88.0	81.0	61.0	45.0	93.0
1847, . .	44.0	47.0	52.0	77.0	84.0	88.0	91.0	85.0	85.0	67.0	70.0	59.0	91.0
1848, . .	56.0	43.0	64.0	74.0	86.0	90.0	87.0	87.0	81.0	70.0	52.0	58.0	90.0
1849, . .	46.0	43.0	60.0	68.0	83.0	92.0	93.0	83.0	70.0	68.0	63.0	43.0	93.0
1850, . .	45.0	52.0	60.0	70.0	73.0	90.0	87.0	87.0	80.0	67.0	63.0	49.0	90.0
1851, . .	48.0	48.0	73.0	67.0	82.0	88.0	87.0	83.0	80.0	73.0	56.0	44.0	88.0
1852, . .	43.2	47.4	53.0	61.0	79.0	84.0	90.0	85.7	85.0	70.0	50.8	56.0	90.0
1853, . .	45.0	51.0	56.4	76.3	84.2	91.3	85.1	91.7	84.7	69.0	59.5	42.8	91.7
1854, . .	50.4	45.0	65.4	70.6	79.0	87.5	97.0	88.5	90.0	75.8	66.0	41.5	97.0
1855, . .	48.0	42.0	57.8	76.0	81.0	92.0	91.6	84.5	85.0	73.0	63.0	46.2	92.0
1856, . .	34.8	38.6	44.9	76.7	89.0	94.0	95.0	87.3	78.9	75.5	61.0	41.8	95.0
1857, . .	37.1	61.8	54.5	58.3	86.4	86.9	90.3	90.3	85.7	73.0	67.0	52.0	90.3
1858, . .	51.4	47.1	57.7	68.1	74.2	90.3	92.0	79.0	85.2	73.0	59.0	42.8	92.0
1859, . .	39.4	44.1	56.6	71.0	86.0	91.5	90.0	81.8	73.8	75.0	65.8	62.9	91.5
1860, . .	50.3	52.0	71.3	68.3	81.0	83.0	84.0	84.4	79.0	69.9	66.7	37.5	84.4
1861, . .	38.0	53.5	56.3	80.3	77.2	84.0	91.7	90.0	82.3	75.5	64.0	51.4	91.7
1862, . .	42.9	40.0	44.5	72.9	84.0	86.0	90.0	88.0	80.0	83.0	68.2	52.0	90.0
1863, . .	52.0	45.3	47.3	77.0	88.0	85.6	85.5	90.0	80.0	71.0	65.4	51.5	90.0
1864, . .	44.2	46.8	53.8	64.8	86.0	93.5	91.9	98.0	80.0	68.7	62.0	49.4	98.0
1865, . .	39.5	45.4	63.7	79.5	85.8	87.0	85.4	90.0	89.0	72.0	68.0	54.9	90.0
1866, . .	40.0	55.0	55.8	84.2	80.0	90.1	94.0	81.6	83.1	73.0	60.8	51.2	94.0
1867, . .	33.5	50.0	53.0	66.0	75.5	85.0	90.0	83.5	80.0	76.0	65.0	46.0	90.0
1868, . .	39.5	45.0	59.8	67.5	75.0	88.7	94.5	85.0	79.5	68.0	58.0	42.7	94.5
1869, . .	49.0	50.6	53.8	74.0	83.0	80.7	89.9	87.2	85.0	71.4	56.9	45.3	89.9
1870, . .	54.3	55.0	50.5	78.0	82.4	93.0	91.2	91.3	83.5	71.5	61.0	47.0	93.0
1871, . .	50.0	50.6	55.5	74.8	92.8	88.2	85.6	85.0	78.0	73.1	62.0	43.3	92.8
1872, . .	42.9	50.0	44.0	84.0	84.1	91.8	91.7	88.8	88.5	69.0	54.0	40.3	91.8
1873, . .	42.3	45.0	49.3	66.2	82.0	90.0	92.4	86.2	85.8	70.5	52.0	57.7	92.4
1874, . .	52.0	49.3	57.2	63.0	86.0	93.0	90.0	84.0	85.8	66.0	60.0	49.0	93.0
1875, . .	35.5	50.0	51.0	63.0	84.7	89.0	91.5	84.8	84.7	70.3	56.2	55.0	91.5
1876, . .	63.0	52.3	59.0	63.3	86.0	87.7	95.0	90.0	90.0	71.1	71.7	42.0	95.0
1877, . .	43.0	50.0	52.8	75.8	84.5	88.0	89.1	87.4	85.7	75.4	66.8	55.2	89.1
1878, . .	44.4	53.3	65.1	73.1	83.2	90.2	92.2	83.3	84.5	77.3	57.2	53.7	92.2
1879, . .	50.1	43.2	51.6	72.4	83.0	90.3	91.4	90.6	85.6	82.6	68.2	54.5	91.4
1880, . .	47.9	57.6	59.8	77.7	93.0	91.1	90.5	88.0	90.0	71.4	59.2	38.9	93.0
1881, . .	38.0	47.0	50.8	78.4	89.0	80.0	87.2	90.8	94.0	86.2	66.7	61.4	94.0
1882, . .	45.0	47.4	56.2	68.0	78.0	90.0	92.1	93.0	87.7	73.8	66.1	48.0	93.0
1883, . .	42.2	43.1	51.1	67.3	89.0	90.8	93.0	86.2	79.8	77.1	67.2	53.1	93.0
1884, . .	40.1	46.0	54.0	70.3	85.2	92.5	93.0	92.4	90.0	78.2	61.0	57.4	93.0
1885, . .	57.0	39.0	50.0	83.0	85.0	89.0	93.0	87.0	81.0	80.0	70.0	65.0	93.0
1886, . .	56.0	52.0	61.0	83.0	82.0	82.0	95.0	90.0	83.8	77.9	65.5	49.0	95.0
1887, . .	47.2	43.8	46.0	74.4	86.5	91.0	93.6	88.0	80.0	74.4	64.8	51.0	93.6
1888, . .	41.0	49.0	49.0	84.0	80.0	94.5	85.5	87.0	76.0	66.0	71.0	56.5	94.5
Mean, .	45.5	47.9	56.3	73.0	83.2	88.6	90.7	87.2	83.2	72.9	62.1	48.9	91.9

Record of the Minimum Temperature from 1838 to 1888, inclusive.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1838, . .	6.0	−5.5	4.0	17.0	30.0	43.0	50.0	41.0	38.0	27.0	3.0	−7.0	−7.0
1839, . .	−13.0	0.0	4.0	22.0	27.0	40.0	49.0	44.0	34.0	22.0	11.0	−2.0	−13.0
1840, . .	−21.0	−14.0	7.0	19.0	34.0	44.0	50.0	50.0	36.0	23.0	18.0	−2.0	−21.0
1841, . .	−17.0	−6.0	8.0	21.0	29.0	43.0	42.0	42.0	46.0	20.0	13.0	5.0	−17.0
1842, . .	−10.0	5.0	13.0	17.0	30.0	34.0	49.0	45.0	30.0	26.0	13.0	−2.0	−10.0
1843, . .	−8.0	−15.0	7.0	15.0	35.0	34.0	47.0	53.0	30.0	28.0	17.0	2.0	−15.0
1844, . .	−22.0	−10.0	5.0	14.0	33.0	42.0	40.0	46.0	26.0	25.0	3.0	−5.0	−22.0
1845, . .	0.0	−3.0	8.0	24.0	30.0	41.0	46.0	42.0	32.0	17.0	12.0	−10.0	−10.0
1846, . .	−1.0	−6.0	2.0	22.0	32.0	41.0	44.0	47.0	37.0	25.0	20.0	1.0	−6.0
1847, . .	4.0	−8.0	9.0	5.0	34.0	42.0	46.0	48.0	35.0	15.0	5.0	3.0	−8.0
1848, . .	−12.0	−2.0	4.0	25.0	32.0	39.0	49.0	44.0	31.0	28.0	11.0	−3.0	−12.0
1849, . .	−8.0	−10.0	12.0	21.0	32.0	39.0	45.0	50.0	37.0	29.0	25.0	3.0	−10.0
1850, . .	−2.0	−11.0	8.0	19.0	31.0	44.0	48.0	44.0	32.0	23.0	16.0	−15.0	−15.0
1851, . .	−5.0	−8.0	12.0	24.0	30.0	41.0	49.0	39.0	29.0	31.0	13.0	−15.0	−15.0
1852, . .	−15.0	−3.4	0.3	23.3	38.5	43.9	55.0	48.9	33.0	24.3	15.0	6.1	−15.0
1853, . .	−2.5	0.5	7.6	27.4	31.8	39.0	54.0	45.9	37.0	24.9	13.8	7.2	−2.5
1854, . .	−9.6	−4.8	14.0	23.7	34.0	39.8	57.7	50.8	33.8	27.0	14.0	−9.0	−9.6
1855, . .	10.7	−16.0	7.8	17.0	41.5	48.0	57.2	44.7	33.0	30.2	15.0	7.0	−16.0
1856, . .	−7.5	−11.0	−9.0	16.5	38.2	48.0	55.9	48.2	41.8	25.0	18.0	−7.0	−11.0
1857, . .	−18.2	−2.7	7.0	14.3	39.8	49.0	55.5	53.6	32.0	25.0	13.0	2.2	−18.2
1858, . .	0.0	−5.0	−8.0	28.5	40.3	51.0	58.5	58.8	37.0	31.5	14.6	0.0	−8.0
1859, . .	−19.4	2.8	3.5	28.7	43.9	45.0	53.0	47.4	41.0	24.8	24.0	−8.5	−19.4
1860, . .	−8.0	−7.2	22.8	23.1	38.9	52.0	53.0	49.1	32.0	28.0	15.0	−7.0	−8.0
1861, . .	−17.0	−20.0	5.5	18.2	33.0	51.0	56.7	48.5	41.6	25.0	17.0	−6.5	−20.0
1862, . .	0.0	−2.0	13.8	24.3	44.0	49.5	51.9	48.0	39.0	26.0	18.0	−1.3	−2.0
1863, . .	5.0	−9.0	−6.0	25.0	38.3	51.0	55.3	48.7	32.0	21.0	18.0	3.2	−9.0
1864, . .	−1.5	−4.3	15.0	31.8	40.0	47.3	53.9	54.8	41.0	28.5	10.8	18.0	−4.3
1865, . .	−4.5	−1.0	13.0	33.0	42.8	55.9	54.8	47.5	35.0	24.2	18.5	6.8	−4.5
1866, . .	−14.5	−1.5	11.5	30.0	40.0	48.0	55.0	48.0	35.5	26.5	16.8	−3.8	−14.5
1867, . .	−5.0	8.0	8.0	29.0	36.0	54.0	55.3	48.3	39.0	27.0	17.5	−3.0	−5.0
1868, . .	0.0	−18.3	−7.3	23.0	36.0	51.8	61.0	51.0	36.2	19.2	23.8	−5.0	−18.3
1869, . .	3.0	−1.0	−9.0	26.7	35.2	47.4	53.5	50.0	36.3	26.8	16.9	−7.5	−9.0
1870, . .	5.0	6.2	6.5	35.0	42.8	53.5	54.5	47.0	40.0	26.0	24.7	1.0	1.0
1871, . .	−5.5	−9.5	24.8	27.0	41.0	51.8	54.0	50.0	32.0	24.3	7.0	−6.5	−9.5
1872, . .	2.5	−2.5	−4.8	29.0	43.7	48.7	59.1	52.9	39.5	29.9	10.0	−8.0	−8.0
1873, . .	−22.0	−2.5	1.8	33.5	39.0	50.6	56.1	49.1	36.2	27.0	6.5	7.0	−22.0
1874, . .	1.2	−5.0	9.7	18.7	39.0	51.3	38.0	46.3	39.0	28.5	16.0	0.0	−5.0
1875, . .	−8.2	−4.0	0.0	22.5	39.8	48.5	53.8	32.0	32.5	26.0	−1.0	−9.0	−9.0
1876, . .	2.8	−1.0	4.5	28.0	39.0	47.0	52.5	49.0	41.2	23.0	18.9	−1.0	−1.0
1877, . .	−3.5	8.5	10.0	32.5	40.0	54.7	58.1	54.8	39.0	25.3	19.4	13.0	−3.5
1878, . .	12.5	−3.2	13.2	37.0	40.5	46.4	55.2	49.9	37.0	27.0	19.8	11.7	−12.5
1879, . .	−4.5	1.0	7.0	32.7	40.0	49.0	56.7	53.2	30.4	20.8	7.7	−6.0	−6.0
1880, . .	2.0	−11.5	13.7	26.2	37.0	51.0	54.0	45.7	39.1	22.9	9.5	−5.0	−11.5
1881, . .	−12.4	−7.0	24.4	22.1	37.0	47.7	59.2	56.7	49.0	29.0	14.0	8.5	−12.4
1882, . .	−15.0	−6.0	17.4	23.7	39.1	52.2	56.3	49.7	43.7	32.2	12.0	0.0	−15.0
1883, . .	−2.5	−1.3	3.0	23.5	43.0	53.7	55.0	43.4	36.2	23.2	18.0	−12.8	−12.8
1884, . .	−8.0	5.1	0.0	31.2	37.6	50.0	57.1	48.8	39.0	26.5	19.8	−10.0	−10.0
1885, . .	−18.0	−15.0	−11.0	19.0	21.0	35.0	41.0	34.0	27.0	24.0	11.0	6.0	−18.0
1886, . .	−22.0	−11.0	−1.0	21.0	29.0	40.0	41.0	39.0	31.6	17.0	15.9	0.8	−22.0
1887, . .	−22.2	−3.8	−2.4	17.1	33.2	38.5	56.0	42.5	29.5	17.0	11.0	−6.0	−22.2
1888, . .	−21.5	−19.0	−3.0	15.0	26.0	38.0	46.0	42.0	25.0	26.0	5.7	3.5	−21.5
Mean, .	−7.4	−5.3	6.0	23.6	36.1	45.9	52.1	47.3	35.6	25.1	14.2	−1.3	−11.7

ALFALFA.

Since the methods of producing this crop, and the conditions under which it promises to be successful are not yet generally understood, it is the plan to present in this paper first, a brief general discussion of the characteristics and value of the crop; second, the results of the most recent experiments on the station grounds; third, results obtained by farmers who have been growing the crop in co-operation with the station; and fourth, brief general directions based upon long-continued experiments for starting and managing the crop.

Characteristics and Value of Alfalfa.

Alfalfa is an exceptionally deep-rooted legume, and under the best conditions it is long lived. Like other legumes it has the capacity, under the right conditions, of assimilating nitrogen from the atmosphere, but until the root system and the nodules which it bears are well developed its growth is greatly promoted by the presence of readily assimilable nitrogen in the soil. It is without doubt one of the most valuable forage plants known to man. It has long been cultivated in various parts of Asia and Europe, whence it was brought to Mexico by the Spaniards, who took it with them to California and the semi-arid portions of our southwestern States. During the past fifteen or twenty years its culture has been steadily pushed eastward, and it is now successfully grown in most parts of the United States and in a few parts of Canada. In many essentials and in feeding value alfalfa resembles the clovers; and as these are so generally known its characteristics will be perhaps best brought out by comparison.

Alfalfa compared with Clovers.

Longer Lived. — Alfalfa is a perennial, while individual plants of the red and alsike clovers, as a rule, live but two years. In regions without excessive rainfall, and in soils richly stocked with lime and thoroughly well drained, a stand of alfalfa is more permanent than a stand of clover under conditions existing in Massachusetts, but in this connection it is important to recognize two facts: —

1. That alfalfa in our soils and in our climate is much less permanent than in the west.[1] Experience everywhere indicates that the probability is that alfalfa will be gradually crowded out here by perennial grasses and clovers, most prominent among which are the Kentucky blue grass and white clover.
2. That it is possible to retain red and alsike clovers in permanent mowings without reseeding, provided a suitable system of top-dressing is followed.

Relative Yield. — Alfalfa grows more rapidly in early spring than either red or alsike clover, and starts more quickly after cutting, and accordingly it may usually be counted upon to give three crops during the season, whereas clover will usually give but two. The first cut of alfalfa is generally superior to either of the others. The total yield on good soils is likely to range from about 3 to 5 tons per acre of well-cured hay in the three cuttings, while red or alsike clovers on similar soils are likely to give about one-quarter less total yield in two cuttings.

Finer Stems. — The stem of the alfalfa plant is relatively finer than that of the red clover. It accordingly cures more rapidly and is usually more palatable, and is consumed with less waste than the coarser red or mammoth clover.

Nutritive Value. — It is popularly supposed, and quite generally stated, that alfalfa is much superior in nutritive value to clovers, but so far as can be determined by chemical analyses made in this station, and determinations of digestibility which have been made here in the department of plant and animal chemistry and in other stations, this does not appear to be the case.

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[1] The winter of 1913-14 has proved very destructive (see p. 170).

Composition of Clover and Alfalfa Hays.

	Number of Analyses.	Water (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
Alfalfa hay, . .	4	13.24	6.38	13.98	28.48	34.70	1.40
Alsike clover hay, .	8	15.00	9.70	14.00	23.10	36.10	2.10
Medium red clover hay,	15	15.00	7.70	13.30	24.30	37.20	2.50

Digestible Nutrients and Energy Values.[1]

	Protein (Pounds in 100).	Fiber (Pounds in 100).	Nitrogen-free Extract (Pounds in 100).	Fat (Pounds in 100).	Net Energy Value (Therms).
Alfalfa hay, ...	10.2	13.9	24.4	.5	34.9
Alsike clover hay, . .	9.2	11.6	23.8	.8	34.6
Medium red clover hay, .	7.7	13.1	24.2	1.4	35.6

It will be noted that alfalfa is relatively somewhat richer in digestible protein than the clovers, but considerably lower in fat. The net energy values, or in other words the productive food values, of alfalfa and the clovers are shown by the trials reported to have been substantially equal.

Soil Improvement.

It has been recognized since the time of the Roman empire, and was perhaps even before that period, that the growth of clover improves the soil, and that all crops give superior results when following it. This knowledge of the facts profoundly affected farm practice many centuries before the peculiarly beneficial effects of clover could be fully explained. We now know that they are a consequence chiefly of two causes: —

1. The penetration of the subsoil by the vigorous root system, opening, mellowing and enriching it.

2. The assimilation of large amounts of atmospheric nitrogen a portion of which remains in the roots and stubble even when the crop is harvested and removed. In both these respects

[1] Based upon average results in the United States.

alfalfa under the best conditions excels the clovers. Its roots penetrate more deeply, and the total crop residue — root and stubble — is greater.

The Soil for Alfalfa.

Alfalfa will thrive on soils of many different kinds, but whatever the type it must satisfy certain conditions: —

1. It should have good depth and be rich, especially in the mineral elements of plant food. Medium loams, inclining rather to be somewhat heavy than light, will give the best crops. The soils which contain too large a proportion of clay retain so much moisture that in open winters the crop, especially when young, is liable to heave.

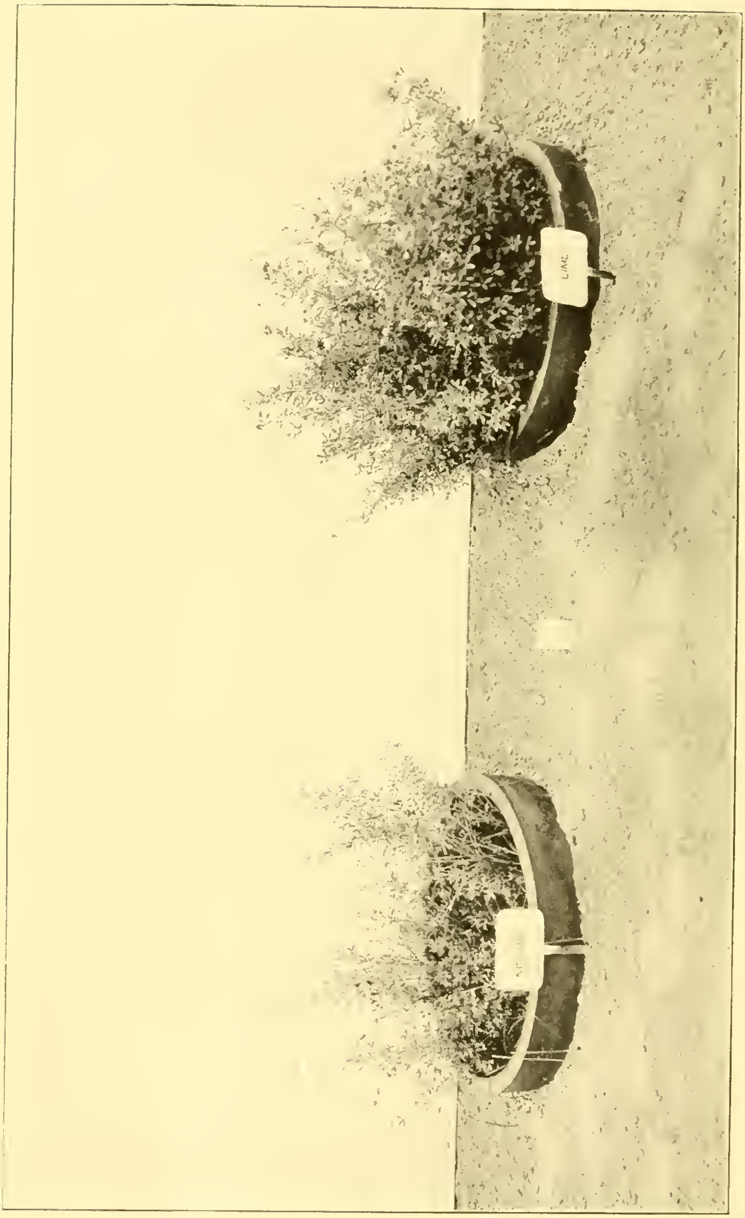
2. Stagnant water in the subsoil is highly injurious. In soils with good capacity to conduct and retain water the presence of standing water in the subsoil (determined by sinking trial holes) within less than 5 or 6 feet of the surface will be highly injurious. If the subsoil be free from standing water to much greater depth it will be a distinct advantage. In the case of soils of coarser texture, which do not conduct water freely in large quantities, and which have deficient capacity to retain water, the water table may be nearer the surface without disadvantage, but even with such soils it would, doubtless, be inadvisable to attempt the cultivation of alfalfa with standing water nearer than 4 or 5 feet below the surface.

3. The field must have sufficient surface slope to carry off water, and there must be no pockets which will retain water. In fields which are too level, or in pockets, the formation of ice on the surface is fatal to alfalfa. It is, of course, possible that in this climate ice may sometimes form on the surface, even on considerable slopes, but this is a danger which cannot be avoided, and it is least on slopes.

4. The presence of a hardpan within less than 10 or 12 feet of the surface, or an excessively compact subsoil, will prove unfavorable; so, also, will a shallow soil underlaid by rock.

5. The soil must not contain free acid, though if this condition exists at the start it can be corrected by the use of lime.

6. The richer the soil naturally is in lime the better suited it is likely to be for alfalfa.


LIME

7. Where sweet clover grows abundantly wild, and where the beech tree occurs in large numbers, alfalfa will usually do well. This is because both sweet clover and the beech are lime-loving plants, and in the case of the sweet clover, moreover, because the bacteria which give it capacity to assimilate atmospheric nitrogen are either identical with those essential for alfalfa or so closely related that they serve the purpose. Inoculation for alfalfa is, therefore, unnecessary in sections where sweet clover grows spontaneously in abundance.

Lime Necessary.

Alfalfa, as already stated, is a lime-loving plant. The soils in many parts of this State are relatively deficient in this element. In most localities, therefore, an application of lime is one of the most important steps in the preparation of a soil for alfalfa. The quantity absolutely necessary will usually range between $1\frac{1}{2}$ and 2 tons per acre; more will usually be beneficial. There are a number of different forms of lime which will serve the purpose. On the heavier soils freshly slaked lime, commercial hydrated lime or fine-ground quicklime will best meet requirements, since these forms of lime will both improve the mechanical condition and correct acidity. On the lighter soils, and especially if deficient in organic matter, air-slaked lime or fine-ground limestone may be preferable. The so-called agricultural limes, or waste lime, slaked in heaps at kilns will meet the requirements in most cases.

Manures or Fertilizers.

Manure. — While manure helps to give the soils the desired texture, and increases the proportion of humus, which may be beneficial, it usually carries weed seeds, and if applied shortly before seeding increases the difficulty of getting a good catch. The free use of manure will, moreover, be likely to increase the competition of grasses with the alfalfa, enabling these in a measure to gradually crowd the latter out. The application of manure in preparation for alfalfa is not recommended by the writer. On the other hand, a free use of manure for crops which precede alfalfa is desirable, especially on the lighter and poorer soils.

Potash. — Alfalfa, in common with clovers and other legumes, does well only when there is a liberal supply of potash in available forms in the soil. Potash fertilizers should be freely used in most cases in preparing for this crop. Potash in the form of sulphate, in the writer's experiments, appears much superior to potash applied in the form of muriate.[1]

Phosphoric Acid. — Although usually relatively less deficient in our soils as compared with the needs of alfalfa than lime and potash, it should be applied in some form, and among the different materials available basic slag meal seems usually to prove best, no doubt because it contains a large proportion of lime.

Nitrogen. — A large amount of nitrogen in the soil is not essential; from some points of view it is undesirable. To give the crop a good start, a fair amount of this element in available form in the soil is essential, but beyond that it is unnecessary and even harmful, — unnecessary because the alfalfa can draw nitrogen from the air, and harmful because it favors the grasses which may drive the alfalfa out.

Varieties.

There are a very large number of varieties of alfalfa now known. Many which may prove valuable have recently been introduced from Siberia by the South Dakota Experiment Station, but these are as yet insufficiently tested. There are but three kinds which deserve attention, known respectively as the common, the Grimm and the variegated.

Common Alfalfa. — This appears to be simply an unnamed strain. If from northern-grown seed, especially seed descended from generations of alfalfa grown in the north, it is fairly hardy and satisfactory.

Grimm. — A specially selected strain which originated in Minnesota; noted for hardiness and productiveness. It took its name from the farmer said to have been one of the most prominent in calling attention to the variety and promoting its dissemination. Comparative trials at this station and in many parts of the northern United States have indicated

[1] See page 157.

this variety to be superior in hardiness and in productive capacity to the common.[1]

Variegated Alfalfa. — This is said to be a cross between common alfalfa and yellow lucerne, a forage crop which is closely related to alfalfa. The flowers vary in color from yellow to greenish purple. This variety is said to be more hardy than ordinary alfalfa and adapted to poorer soils. Where either the common or the Grimm can be grown they are preferred to the variegated, which is characterized by decumbent growth, greater consequent tendency to lodge and lower feeding value. This variety has not been tested in the Massachusetts Experiment Station.

Obstacles to Success.

Diseases. — Relatively few diseases have proved troublesome in Massachusetts. The only important one is leaf spot, which is most injurious on newly sown areas. The spots, which usually appear first on the lower leaves of the plant, are yellow to dark reddish brown in color. Sometimes the lower leaves only are affected, in which case not much damage will be done, but in cases of bad infection, and under favorable weather conditions (hot, humid air and frequent showers), the trouble may spread rapidly; all the leaves turn yellow and gradually fall. In such cases the disease if unchecked greatly enfeebles the plants, and weeds, grasses or clovers tend to displace the alfalfa. No preventive treatment is known, but the disease can usually be checked and healthy growth re-established by cutting, and whether the alfalfa be young or old it should be promptly cut if the disease appears to be serious and rapidly spreading toward the upper leaves. If the field is newly sown and the crop only a few inches high the cutting should not be too close, and what is cut may be allowed to lie where it falls. If the new growth is not healthy the field should be recut. In the case of an established field the forage may be either made into hay or fed green.

Dodder. — This is a parasite characterized by abundant development of thread-like reddish-yellow stems, attached to

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[1] See page 156.

the stems of the alfalfa and bearing inconspicuous flowers of the same color. This parasite tends to spread rapidly; it renders the crop unpalatable. If noticed in the field it is best to cut the crop and burn it, plow the field and not put it into alfalfa again for a considerable number of years. Alfalfa dodder is not yet general in this State, and most energetic measures should be taken to exterminate it where it appears. If it shows in a field it is safe to conclude the seed of the dodder was mixed with the alfalfa seed. It is so fine it usually escapes detection by the average buyer. Dealers should be asked to guarantee alfalfa seed free from dodder. In cases of doubt samples of seed should be sent to the experiment station for examination.

Weeds. — Annual weeds will give but little trouble, provided such methods of seeding as are later recommended are followed. Especially is this true if the thorough preparatory tillage recommended when the seed is to be sown in late summer is followed. In the case of spring seeding, either with or without a nurse crop, annual weeds may compete with the alfalfa for water and food. If the growth is thick and rank the weeds may be clipped with a mowing machine set about 3 inches high. It is a mistake to sow alfalfa in fields heavily infested with the roots or seeds of perennial weeds. Especially is this true of witch grass, the competition of which alfalfa is wholly unable to withstand.

Grasses and Clovers. — In our better soils, and with our humid climate, some of the grasses and clovers, particularly Kentucky blue grass and white clover, tend to come in and gradually to crowd out the alfalfa. The tendency in this direction is increased by the use of barnyard or stable manures which, besides supplying large amounts of nitrogen (highly favorable to the growth of grasses), often carry their seeds as well as those of clover. It cannot be regarded as good practice to top-dress a well established field of alfalfa with manure of any kind. So doing, besides being objectionable from the points of view already stated, must be regarded as wasteful of nitrogen, the most costly plant-food element, since the alfalfa if well established is able to take this element so largely from the air.

It is possible, by the use of a harrow at the proper season, to in a measure check the coming in of grasses and clovers. These are more shallow rooted than alfalfa and may, therefore, be uprooted without much injuring the latter. A spring-tooth harrow properly set is the most effective type, and a special form of tooth has been designed for this particular use. This implement is advertised as the alfalfa harrow. Its use is most effective when the soil is relatively dry, and immediately after cutting either the first or the second crop will usually prove the best time for the operation.

Winterkilling. — Any one of the following causes may, under unfavorable conditions, destroy alfalfa: —

1. Heaving, which is most serious on the heavy soils. Tendency to this is much reduced by allowing a relatively heavy growth to remain in the field for winter protection. Perfect underdrainage, natural or artificial, of course lessens the tendency to heave, which is greater in proportion as the water content of the soil increases.[1]

2. Formation of ice on the surface. This is something which, under extreme weather conditions, may affect any field, but the tendency to this injury is comparatively small in fields where the slopes are such as to rapidly carry off surface water.

3. The presence of free acid in the soil, for this weakens the plant, rendering it susceptible to unfavorable conditions of any kind. The remedy is of course the application of lime.

4. Insufficient winter protection, due to too late cutting or excessive or overlate pasturing.

Recent Experimental Work with Alfalfa at this Station.

The more important of the recent experiments with alfalfa in this station have been as follows: —

1. Comparison of Grimm with the common alfalfa.

2. Comparison of high-grade sulphate with muriate as a source of potash.

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[1] Much alfalfa was killed during the year of 1913–14. The cause is not surely known; but it seems possible it was due in a measure to the large amount of water in the soil, owing to heavy fall and early winter rains (see p. 170).

3. Comparison of different methods of seeding.
4. A test of a commercial culture for inoculation.

In addition, we have had under constant observation a number of plots of different ages on which observations as to the gradual displacement of the alfalfa by grasses and clovers have been made.

1. *Grimm compared with Common Alfalfa.*

For a number of years it has been our object to make careful comparisons of the Grimm alfalfa with the common variety from northern-grown seed. Our first trials were begun in 1909, but although we obtained what we supposed to be Grimm seed of the very best quality from a grower recommended by the Minnesota Experiment Station, and believed to be absolutely reliable, our first experiments were a failure. There were no essential differences either in the appearance or the yield, and the party who furnished the seed later wrote us that a mistake had been made, that the seed sent as Grimm was not true to name. He supplied us, without charge, with seed of the genuine Grimm. This was sown after very careful preparation of the soil on a field where alfalfa had been previously grown in the late summer of 1911.

The land used in this experiment comprised two plots. Both have received annually for the past twenty-three years an application at the rate of 600 pounds per acre of fine-ground bone meal. One of the two plots has in addition annually received a liberal application of muriate of potash, for the last thirteen years at the rate of 250 pounds per acre; the other plot has annually received the same amount of actual potash, but in the form of high-grade sulphate, and for the last thirteen years at the rate of 250 pounds to the acre. Under both systems of manuring the Grimm alfalfa has given yields considerably larger than those obtained from the common. The results both for 1912 and 1913 are shown in the following table: —

Comparison of Varieties of Alfalfa and Source of Potash.

	Muriate of Potash.		High-grade Sulphate of Potash.	
	Grimm (Tons per Acre).	Common (Tons per Acre).	Grimm (Tons per Acre).	Common (Tons per Acre).
1912.				
1st cut,	2.122	1.56950	2.21875	1.98225
2d cut,	.465	.29075	.76925	.59150
3d cut,	.750	.63950	.94675	.82225
Totals,	3.337	2.49975	3.93475	3.39600
1913.				
1st cut,	3.08500	2.61600	2.94650	2.66250
2d cut,	.63935	.36045	1.00590	.71000
3d cut,	.40685	.29650	.57395	.50295
Totals,	4.13120	3.27295	4.52635	3.87545

The area of the plots used in these experiments is one-eighth acre each. The averages of both plots for the two years are: for the common alfalfa, 3.261 tons per acre; for Grimm alfalfa, 3.982 tons per acre, — a difference of about 22 per cent., greater yield in favor of the Grimm. In 1912 the yield of the Grimm alfalfa was 23 per cent. greater than that of the common. In 1913 both varieties yielded larger crops than in 1912, the yield of the Grimm being 21 per cent. greater than that of the common. The superiority of the Grimm as compared with the common is shown to have been no greater in the second year than the first. There is, therefore, no indication to date that the Grimm will prove more permanent than the other.

2. *Comparison of Potash Salts for Alfalfa.*

In one of the fields (Field B) of the experiment station grounds, the soil of which is a medium loam with compact and moderately clayey subsoil, alternate plots of one-eighth acre each have been continuously fertilized respectively with muriate and high-grade sulphate of potash in equal amounts for the past twenty-one years. These salts have been applied since 1900 at the rate of 250 pounds per acre each. Throughout the entire period (twenty-one years) these plots have each had an annual application of fine-ground bone meal at the rate of 600 pounds per acre. Throughout this entire period no manure has been applied to the land, and no other fertilizer of any kind with the exception of lime. Hydrated lime at the rate of 2 tons to the acre was applied broadcast upon the rough furrow in April, 1910, and deeply worked in by the use of the disk harrow.

Two plots in this field were sown to common alfalfa on Aug. 2, 1910. The seed did not germinate well, and the growth being too thin the plots were plowed July 12 and reseeded Aug. 5, 1911. One-half of each plot was sown to Grimm alfalfa and one-half to the common northern-grown seed. The yields on the two plots are shown in the table, page 157. It will be noticed that in every case the yield obtained on the sulphate of potash has been materially greater than that obtained on the muriate. The average rates of yield per acre for the two years on the two potash salts have been as follows: —

	Muriate of Potash (Tons per Acre).	Sulphate of Potash (Tons per Acre).
Grimm alfalfa,	3.734	4.231
Common alfalfa,	2.886	3.636

Whenever the crop is in active growth (and this has been true almost ever since the little seedlings appeared above the surface) there is a striking difference in the shade of green of the foliage on the two potash salts. The leaves on the sulphate of potash plots are of a much darker shade, which would be characterized as dark green. Those on the muriate of potash plots are much lighter. The shade would be characterized as yellowish or pea green. A similar difference in shade of foliage has been noticed in the case of other plants when grown on these potash salts. It is believed that this indicates a difference in character or number of the chlorophyl bodies of the two types of plants, — a difference which we have not, however, been able to demonstrate by scientific tests, but which apparently gives the chlorophyl bodies of the darker green plants a higher degree of functional activity.

Bone and muriate. Bone and sulphate.

3. *Spring and Summer Seeding compared.*

In the spring of 1910 a small area of silt loam soil, underlaid by gravel at the depth of 4 or 5 feet, was selected for the purpose of comparing the results of seeding in early spring with a nurse crop with the results of seeding in summer after bare fallow with sufficiently frequent harrowing to keep down weeds. The soil in question had been used during a number of years for a variety of crops including potatoes, corn and a test of varieties of alfalfa. Previous crops had been raised on fertilizers. No manure had been applied for many years. The soil contained a great many seeds of annual weeds, but it was not infested with the roots of perennial weeds. The entire field was limed on May 19 at the rate of $1\frac{1}{2}$ tons agricultural lime. On one-half of the field fertilizers at the following rates per acre were applied and harrowed in: —

	Pounds.
Basic slag meal,	1,500
High-grade sulphate of potash,	350
Nitrate of soda,	125

The spring sowing was made on May 19, with oats at the rate of 1 bushel per acre as a nurse crop. Fertilizers were applied to the other half on July 1, and the summer sowing was made on August 1.

From the spring-sown plot a fair crop of oats (somewhat mixed with weeds) was harvested in July, and in addition from this plot on September 21 was harvested a crop of alfalfa hay at the rate of 1.41 tons per acre. The yields from the two plots in the following year were as follows: —

Spring-sown alfalfa at the rate of 3.44 tons per acre.

Summer-sown alfalfa at the rate of 3.34 tons per acre.

From the statements so far made the conclusion must clearly be that the spring sowing had distinct advantages over summer sowing. We have first to its credit a fair crop of oat hay and a moderate crop of alfalfa the season of sowing; and second, the yield the following year was slightly greater than on the summer-sown alfalfa. There is, however, one point connected with the results distinctly unfavorable to the spring sowing, viz., the proportion of weeds in the product was much greater than in the crop from the summer sowing. The weeds were not separated from the alfalfa the first year, and during the second year only from the second cutting. The method followed was this: just previous to the second cutting, one square yard in each plot, which seemed as a result of careful examination to be fairly representative in both cases, was selected, and the entire product cut and separated into three classes, viz., alfalfa, grass and clover, and weeds. The results reduced to a percentage basis are shown in the following table: —

	Spring-sown Alfalfa (Per Cent.).	Summer-sown Alfalfa (Per Cent.).
Total weight,	100	100.0
Alfalfa,	65	86.6
Grass and clover,	15	1.6
Weeds,	20	11.6

4. *Inoculation.*

Two experiments in inoculation by the use of a commercial culture have been tried. The first was upon land fertilized annually for a long series of years with bone meal at the rate of 600 pounds, and muriate of potash at the rate of 200 pounds, per acre (Field D). The land had been used for a considerable variety of crops. No alfalfa had previously been grown on it.

The soil is a medium loam with a compact subsoil containing considerable clay. The culture employed was Farmogerm [1] and it was used, in accordance with directions, for the treatment of the seed before sowing. In preparation for the crop the soil received an application of lime applied to the rough furrow (and deeply worked in) at the rate of 3,500 pounds per acre. The grade of lime used was a so-called agricultural lime containing some hydrate, but mostly in the form of carbonate. The land also received a mixture of fertilizers at the following rates per acre: —

[1] Farmogerm is made by the Earp-Thomas Farmogerm Company, Bloomfield, N. J. There are now numerous other commercial cultures on the market, and numerous colleges and experiment stations (this one among them) are now furnishing cultures for all legumes at cost to citizens of their respective States. No effort to compare the different cultures has been made in this station.

	Pounds.
Basic slag meal, ...	1,500
Muriate of potash, ...	500

This was deeply harrowed in. In addition, just previous to the last harrowing, a mixture of equal parts of nitrate of soda and fine-ground bone was applied at the rate of 500 pounds per acre.

The treatment of the soil brought it into a condition believed to have been highly favorable to bacterial activity; and the preparatory tillage had been such that it was moderately compact below, with the surface in fine mechanical condition and mellow. The seed was sown July 29. It germinated well and the ground was well covered, the crop being some 10 inches or more in height before cold weather set in.

The second experiment was upon a somewhat lighter soil (North Field) which would be characterized as a silt loam, underlaid with gravel of moderately open texture. This land had been annually manured for a considerable number of years with well-preserved manure from dairy cows. The rate of application had been moderately heavy. It had been used for a variety of forage crops in rotation, but no alfalfa had been grown upon it.

The preparation of the land and the general treatment were very similar to those in the other experiment. Lime was applied at the rate of 4,000 pounds per acre, basic slag meal at the rate of 600 pounds, and muriate of potash at the rate of 800 pounds per acre, and these were deeply incorporated with the soil by the use of the disk harrow. Just before seeding, a mixture of nitrate of soda and fine-ground bone meal in equal parts was applied at the rate of 400 pounds per acre. The seed was sown July 27, and as in the other field germination was perfect, and the ground well covered with abundant growth for protection during the first winter.

The seed used in both experiments was of two kinds: Montana-grown common alfalfa, and a variety which had been purchased under the name Grimm but which was later found not to have been true to name. It was, however, like the other, northern-grown seed; and the crops from the two kinds of seed showed no appreciable differences. The rates of yield are shown in the following table: —

	Field D.			North Field.		
	Inoculated (Tons per Acre).	Uninoculated (Tons per Acre).	Gain per Acre.	Inoculated (Tons per Acre).	Uninoculated (Tons per Acre).	Gain per Acre.
1910.						
1st cut,	2.33	1.97	.355	2.70	2.44	.257
2d cut,	1.02	.88	.140	1.63	1.54	.090
3d cut,	1.43	.98	.450	1.41	1.39	.020
Totals,	4.78	3.83	.945	5.74	5.37	.367

It will be noted that in both experiments there was considerable gain due, in so far as can be judged, to the use of the culture. An examination of the roots at a number of different points in the early spring of 1910 showed, however, that there were nodules on the uninoculated as well as on the other, and in both cases by the end of the season there was no difference which could be detected by close observation in the appearance of the inoculated and uninoculated plots. In 1911 the growth of the uninoculated was fully equal to that of the inoculated, and the weights were not separately taken. The value of the increase in the yield the first year, supposedly due to the inoculation, was, however, much greater than the cost of the culture ($2 for an acre) and the labor entailed in using it. The conclusion appears, therefore, to be justified that when alfalfa is put upon land on which the crop has never been grown the use of a commercial culture is likely to be profitable.

The rates of yield per acre on these fields in succeeding years are of interest in this connection. They show conclusively that on suitable soils rightly managed alfalfa is a valuable crop. The yields are shown in the following table: —

	Field D (Tons per Acre).	North Field (Tons per Acre).
1911,	2.72	2.80
1912,	2.99	3.58
1913,	3.89	4.97

The manurial treatment previous to the introduction of alfalfa in these fields, and the kinds and amounts of materials applied in preparation for the crop, have been given. Subsequent fertilizer treatment has been as follows: —

Field D. — From 1910 to 1912, inclusive, this was annually top-dressed with bone meal at the rate of 600 pounds, and muriate of potash at the rate of 200 pounds, per acre; and in 1913 the rate of top-dressing was basic slag meal 1,000 pounds, muriate of potash 200 pounds, per acre.

North Field. — This field received no top-dressing in either 1910 or 1911, but in 1912 and 1913 it was top-dressed with basic slag meal at the rate of 1,000 pounds, and sulphate of potash at the rate of 100 pounds, per acre.

In both fields the alfalfa is now considerably mixed with grasses, principally Kentucky blue grass and white clover. The yield, however, on both is still very large, and as both Kentucky blue grass and white clover rank exceptionally high in nutritive value the quality of the hay, though not pure alfalfa, is still much above the average in feeding value. An effort has been made to diminish the proportion of grass and check its spread in the North Field by thorough disking. This operation was carried out in the summer of 1912, immediately after the harvesting of the second crop. The result was a very material improvement.

Co-operative Experiments with Alfalfa

In Part I. of the twenty-third annual report the plans for the co-operative experiments now to be discussed were fully reported. These experiments were 33 in number. They were quite evenly distributed throughout the State, and were located on farms belonging to men especially recommended as well fitted for such work. The experiment station furnished the best obtainable seed. The soil was thoroughly prepared, the seed was inoculated with Farmogerm [1] and sown in the late summer of 1910. Three reports have been made by the farmers co-operating in this work.

The first of these reports was published in Part II. of the twenty-fourth annual report. This had reference to the conditions about the middle of May in 1911. Twenty-nine

[1] See page 160.

written reports only were received. The results may be classified as follows: successful experiments, 13; partially successful, 9; failures, 7.

Two other reports direct from the farmers have since been received: the first of these, made during the winter of 1912–13; the second, during the winter of 1913–14. On each occasion there was a diminished number of farmers responding, indicating, no doubt, failure on the part of most of those who did not report. The number of growers reporting in the winter of 1912–13 was 24. Of these, 6 were entirely successful, 8 partially successful and 10 had experienced failure.

At the time of the last report, in the winter of 1913–14, only 9 growers responded. Of these, 5 were successful, 1 partially successful and 3 had experienced failure.

The results obtained might be considered discouraging but for the fact that the causes of failure in most cases would seem to be avoidable. These causes, in the order of their importance, may be classified as follows: —

1. *Winterkilling.* — This appears to have been due in most cases to poor drainage or to too flat a surface, permitting standing water and ice. In some cases winterkilling seemed to be a consequence either of the fact that the seed was sown too late, or that the weather immediately following sowing was so dry that the crop did not get a good start. As a consequence of either of these conditions the first winter found the crop with insufficient growth for protection.

In other cases winterkilling was a consequence, also, of insufficient winter protection, but this was due either to the fact that the alfalfa was pastured too late in the fall or that the last cutting was made too late.

2. *Weeds and Grasses have crowded the Alfalfa out.* — This has occurred mainly on fields which either did not get a good start in the beginning, owing to imperfect germination of the seed, or on fields which were partially winterkilled, thus giving weeds and grasses opportunity to come in.

In some cases, however, the competition both of weeds and grasses with the crop has been accentuated by the use of manure as a top-dressing.

Among all the different weeds and grasses mentioned as crowding out alfalfa, witch grass is the one most frequently mentioned. It is perfectly clear that sowing alfalfa in land infested with witch grass is highly unwise.

Yield obtained. — The range of yields in the successful experiments as reported by the growers (in part estimated) is from 1 to 6 tons per acre. This wide variation reflects the extreme differences in character of soil as regards physical characteristics and fertility, and also, no doubt to some extent, the difference in thoroughness in the work of the different farmers concerned. The average yield per acre of the 7 growers who reported definitely is 3.2 tons.

The Dates of Cutting. — There has been considerable diversity of practice, in spite of the fact that very definite advice was given, in the dates of cutting. The range has been about as follows: the first cutting from June 17 to June 28; the second, July 20 to August 20; the third, August 25 to September 25.

The Opinions of Growers. — The following is a list of the farmers who are co-operating in this work and a brief statement of their opinions as to the value of this crop for the section of the State in which they live: —

C. M. Cudworth (*Cummington*). — Consider it a profitable crop if clover and timothy can be kept out.

John H. Bartlett (*Nantucket*). — I think it is a valuable crop to raise. I am going to put in more this season.

Lovett Brothers (*Oxford*). — Have reseeded. New stand gives promise of a good crop.

C. W. Prescott (*Concord*). — The crop is holding its own and doing well considering that no plant food has been applied since planting. One-half acre seeded to Grimm has been a wonder.

Edward Kirkham (*Holliston*). — Crop has gradually died out. Shall not try it again on my heavy soil unless I do some tile draining.

Lyman P. Thomas (*Rock*). — Crop winterkilled because of the mistake made in pasturing too late.

Charles L. Clay (*North Dana*). — Still believe it to be a profitable crop if witch grass can be kept out.

Paul Cunningham (*Bolton*). — Crop was killed out by drought of 1911.

H. A. Parsons (*North Amherst*). — Results indicate crop to be valuable. Seeded 1 9/10 acres more.

Cyrus S. Bardwell (*Shelburne*). — Do not believe the crop is suited to this vicinity.

G. B. Trowbridge (*South Weymouth*). — The dry weather has a bad effect upon alfalfa; at least it seemed to kill most of mine after the first crop was cut.

J. B. Sawyer (*Bradford*). — Crop suffered because of the severe drought in 1913.

Howard W. Foster (*Lowell*, R. F. D. No. 1). — Condition of the crop compared with a year ago is much better.

John L. Smith & Son (*Barre*). — If it were not for witch grass should sow the rest of the field.

H. K. Herrick (*Blandford*). — Results obtained are encouraging. Shall try more.

Selection of Seed.

The experiments described in earlier pages indicate that the Grimm [1] alfalfa is superior to the common, but the latter has given satisfactory results in many cases. Whatever the variety, it is important that northern-grown seed be selected for New England use; and not only that the seed purchased for sowing shall have been grown in the north, but it should be descended from as many generations as possible of northern-grown alfalfa. It will be wise, as already pointed out, to purchase only on guarantee that the seed is free from admixture with the seed of dodder.[2] Where this parasite becomes established success with alfalfa becomes impossible.

Time and Method of Seeding.

Alfalfa may be sown with success either in early spring with a nurse crop or late in summer with corn or alone. Sowing alone in late summer is attended with less risk than any other method.

Spring Sowing. — Alfalfa sown in spring will usually start well, but in order to keep down the annual weeds which are almost sure to be abundant in our better soils it is essential to put in a nurse crop; and at the season when this is cut the weather is frequently so hot and dry that the young alfalfa is seriously injured. When seeding in spring it is recommended that the quantity of alfalfa seed should be about 25 to 30 pounds per acre. Either oats or barley will serve best as a nurse crop, and about 1 bushel of either will be sufficient.

Seeding in Corn. — In some cases seeding to alfalfa in the standing corn according to the method of seeding to grass,

[1] See page 156. [2] See page 153.

which is so commonly followed in the Connecticut valley has given successful results. This method, however, can be expected to succeed only when conditions are highly favorable. The soil must be one of fine texture, in perfect tilth, and naturally retentive of moisture. The corn field must be free from weeds, the corn must not be over thick, nor the growth excessively rank. If either of the last-named conditions exists the alfalfa will not make sufficient growth to go into the winter with adequate protection. If the corn is to be cut for the silo the alfalfa will be more likely to succeed than in field corn, for during the interval between the cutting of ensilage corn and cold weather it may make considerable growth. The best date for seeding in this manner is usually about the end of July. Showery weather should be selected if possible, and the quantity of seed should not be less than 30 pounds per acre.

Summer Seeding alone. — This method of seeding has given more uniformly successful results than any other which has been tried in the station or upon the college grounds; indeed, with proper preparation it has never failed. The following is a brief outline of the most successful practice: —

1. Plow the previous autumn, or in spring as early as the ground can be worked.

2. Apply a heavy dressing of lime to the rough furrow either in fall or early spring and disk in at once.

3. As early in the spring as weed seeds begin to germinate apply the following mixture per acre: basic slag meal, 1,500 pounds; high-grade sulphate of potash, 400 to 500 pounds; and disk it in.

4. Between the date of the last operation and the date of sowing the seed (which should not be later than the last of July) harrow about once in ten or twelve days.

5. When ready to sow the seed apply per acre nitrate of soda, 100 pounds, basic slag meal, 300 pounds, mixing them and harrowing in lightly.

6. Sow 25 to 30 pounds of seed per acre, inoculating it if alfalfa has not been successfully grown on the land before, and cover as you would grass seed.

7. Inoculation may be effected either by the use of a com-

mercial culture, a culture which will be furnished by the college, or the incorporation of soil from a successful alfalfa field with the soil of the field to be sown. Inoculation of the seed is usually least expensive and fully as successful as the use of soil, but if the latter method is adopted sow 300 or 400 pounds per acre. It should be spread (in cloudy weather if possible) and at once harrowed into the soil. Cultures are most effective when fresh. They gradually lose vitality on keeping, and in ordering, whether from a commercial house or the college, the date when the culture will be used should be specified.

8. However luxuriant and abundant the growth following summer sowing, whether in corn or alone, it will not be advisable in the severe climate of New England to cut or pasture the crop. Even if the growth be a foot to a foot and a half in height it is worth more left in the field, and will not interfere with the development of the crop or the harvesting thereof the following season.

Harvesting Alfalfa.

Whatever the stage of development alfalfa should be harvested as soon as the buds or suckers which start near the base of the plant are well developed. This will usually be when the alfalfa is in early bloom. If allowed to stand much beyond the period of early bloom the plants start slowly after being cut, and the total yield of the season will be relatively small. In every case, however, before cutting examine the stem close to the ground to determine whether the basal buds are starting to grow. Whenever the cutting of the crop is too long delayed the result is a decrease in the total yield of the season. The last cutting should never be so late that the crop will not make growth sufficient for winter protection, and experience leads to the conclusion that in this climate this should be at least some 6 to 8 inches in height.

After cutting, alfalfa should be allowed to lie, with possibly one turning, until it is wilted. It should then be put into windrows which, if the weather is bad, may need to be turned once, and later into cocks where it should be allowed to remain until cured. Hay caps should be used if possible. Should the time required in curing it exceed about five days the cocks should be moved to avoid injury to the roots, and it is desirable, as in the case of clover (which is often similarly handled), to remove the caps and open or turn over the cocks on the morning of a good day, when it is judged to be sufficiently cured to be put in.

Top-dressing.

If the crop has been successfully inoculated, or if the nodules which have been referred to are abundant on the feeding rootlets of the alfalfa, it will not be necessary to top-dress with materials furnishing nitrogen, or at least if such materials are at all required (as may be the case upon soils which are naturally very poor and light) they should be used only in moderate quantities. If used freely, nitrogen stimulates the growth of grasses which, therefore, are all the more likely to crowd out the alfalfa. On the other hand, it is necessary in order to secure large crops that the mineral elements of plant food be accessible in abundance. If then the soil is not naturally richly stocked with phosphoric acid and potash these must be supplied, and the following mixture of materials is recommended annually per acre: basic slag meal, 800 to 1,200 pounds; high-grade sulphate of potash, 175 to 250 pounds; or low-grade sulphate of potash, 350 to 500 pounds. This mixture may be applied either in the autumn or in very early spring.

If basic slag meal is used as a source of phosphoric acid it is believed that a second application of lime will not be necessary, but if any other material is selected as the source of phosphoric acid a top-dressing with lime once in two or three years is likely to be beneficial.

Summary.

The following conclusions and advice appear to be warranted on the basis of the results obtained in the experimental work and practical experience of this institution: —

1. Alfalfa is superior to red and alsike clovers in holding the land longer, giving a somewhat greater average yield, and in fineness and palatability. The net energy value is about the same as that of good clover, but alfalfa hay is richer in protein and therefore better supplements corn silage, corn

fodder or corn and reduces the expenditure necessary for concentrated feeds.

2. Cultivation of alfalfa greatly improves the soil as a result, chiefly, of the deep penetration of its great tap roots and of the assimilation of atmospheric nitrogen which is left behind in large quantities in roots and stubble.

3. Alfalfa will thrive on almost all thoroughly drained soils, but the field should have considerable surface slope, and a soil rich in lime is best.

4. A heavy application of lime is in almost all cases necessary, usually from $1\frac{1}{2}$ to $2\frac{1}{2}$ tons at least.

5. On soils which are low in humus and relatively poor, one good application of manure plowed in is beneficial, but in general, fertilizers should be preferred to manure because less likely to bring in weeds, grasses and clovers.

6. The best source of potash for the crop is sulphate, and one of the best sources of phosphoric acid is basic slag meal.

7. The Grimm variety is superior.

8. Among the principal obstacles to success are leaf spot or rust, which can be prevented by cutting when it first appears; dodder, which can be avoided by care in the purchase of seed; the competition of weeds, grasses and clovers, which is reduced by avoiding manures or fertilizers rich in nitrogen; and winterkilling, which is due to poor drainage, formation of ice and insufficient growth for protection.[1]

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[1] Since this bulletin was written we have had opportunity to note the condition of alfalfa upon the station and college grounds in the spring of 1914. There is more winterkilling than for many years; and reports received from different correspondents indicate that the winter of 1913-14 has destroyed a large portion of the alfalfa in the State. A great deal appears to have been destroyed also in Connecticut.

The older seedings have in general suffered more than newly seeded areas, but in one case at least, reported by a large grower in Connecticut, the opposite was true.

The minimum temperature records were not exceptionally low, but from the middle of January until about the end of February the average temperature was low, and when lowest there was little snow protection. The principal known difference in conditions during the winter of 1913-14, and the winters of the recent years during which alfalfa has suffered little injury, was the higher proportion of water in the soil due to heavy autumn and early winter rains. It is the writer's belief that this was an important predisposing cause of injury. Alfalfa will endure extreme cold in relatively dry soils, but in soils containing a large proportion of water such temperatures subject its root system to most unfavorable conditions.

The Grimm variety has suffered far less than the common, even when the seed from which the latter was started was northern grown. In the light of existing conditions the writer's conviction is strengthened that our farmers will be wise not to depend too exclusively upon this crop. He would particularly urge that even although the seed be considerably higher in price, all farmers undertaking the growth of alfalfa should, for the present, plant Grimm variety, and as the demand for this seed is heavy and the price high he calls attention to the fact that there will be much temptation to substitute seed not true to name. The utmost care should be taken, therefore, to purchase only from parties known to be reliable.

9. The method of seeding attended with least risk is sowing alone in late summer after most careful preparatory tillage.

10. Inoculation of the seed is desirable when the crop is sown upon new land, and cultures used in accordance with directions are to be preferred to the use of soil in most cases.

11. In the co-operative experiments reported there is a large proportion of failures, but these appear to have been due to preventable causes, and the results are on the whole encouraging.

12. The crop should be cured with little exposure to direct sunshine and little handling to avoid loss of leaves.

13. It is a mistake to sow alfalfa in fields infested with witch grass.

14. The growth of weeds, grasses and clovers can be largely prevented by harrowing after the first or second cutting of any season when they are first present in noticeable proportion.

15. Annual top-dressing with slag meal and potash will in most cases be desirable.

COMPOSITION AND USE OF SOME OF THE NEW FERTILIZER MATERIALS; ALSO, FERTILIZING VALUE OF SOME LOCAL BY-PRODUCTS.

H. D. HASKINS.

In the large number of miscellaneous materials forwarded to the experiment station laboratory there occasionally appears a new fertilizing product or by-product of value to farmers living in the vicinity of the establishment which produces it. Oftentimes it may be a poorly balanced fertilizer, although if supplemented with chemicals or other fertilizing ingredients it may prove efficient. The large number of inquiries received regarding such products as sources of plant food would indicate the desirability of publishing a brief statement as to their use.

No. 1. Sheep Manure and Wool Waste.
No. 2. Wool Waste extracted of Grease (Sud Cake).

Analysis.

	No. 1.	No. 2.
Moisture,	4.99	44.80
Potassium oxide,	2.89	.37
Phosphoric acid,	.31	.03
Total nitrogen,	1.27	1.30
Water soluble nitrogen,	.51	.27
Active water insoluble nitrogen,	.30	.51
Inactive water insoluble nitrogen,	.46	.52
Approximate commercial value per ton,	$6 48	$4 00

Sheep Manure and Wool Waste (*No. 1*). — This manure, which is quite thoroughly dried, may be used at the rate of 4 to 5 tons per acre for corn; when used in seeding to grass, this application should be supplemented by 500 pounds of basic slag phosphate. Some of the commercial sheep manures, particularly those from wool-carding establishments, often carry large quantities of noxious weed seeds.

Wool Waste extracted of Grease (Sud Cake) (No. 2). — This product would be more suitable for corn and to fit land for seeding to permanent meadows than for potatoes or other hoed crops. It can be used to advantage on all soils deficient in organic matter and humus. Five tons per acre may be used to good advantage for corn or seeding to grass. In addition it would be well to use 150 pounds of muriate of potash and 500 pounds of basic slag phosphate.

No. 3. Fine-ground Foreign Whale Guano.
No. 4. Rockweed.
No. 5. Crude Unground Garbage Tankage.

Analysis.

	No. 3.	No. 4.	No. 5.
Moisture,	–	15.66	64.89
Potassium oxide,	None	1.81	.11
Phosphoric acid,	9.90	.23	.81
Total nitrogen,	8.16	.60	.78
Water soluble nitrogen,	2.08	.09	.15
Active water insoluble nitrogen,	3.43	.15	.10
Inactive water insoluble nitrogen,	2.65	.36	.53
Approximate commercial value per ton,	$37 00	$3 35	$1 80

Fine-ground Foreign Whale Guano (No. 3). — Whale guano is quite similar in composition to dry ground fish. Its nitrogen availability is probably about 67.50 per cent., while that of fish averages about 70 per cent. The whale guano carries quite a high percentage of fat (13.82 per cent.), which will probably prevent its nitrogen from becoming as quickly available as that in fish scrap.

Rockweed (No. 4). — Rockweed may be used broadcast at the rate of 5 to 6 tons per acre, and thoroughly worked into the soil by means of a disk harrow. The use of lime with this material will ordinarily be found advantageous, — from one-half to one ton per acre. The product carries but a small amount of phosphoric acid; the use, therefore, of 400 pounds of basic slag phosphate or acid phosphate per acre for crops such as corn and seeding to grass will usually be found both economical and effective. Rockweed may be used to advantage on any soil deficient in organic matter and humus. It is not a well-balanced fertilizer, however, and should ordinarily be supplemented by an application of some source of available phosphoric acid.

Crude Unground Garbage Tankage (No. 5). — Crude garbage tankage, undried and unground, is necessarily a coarse, slow-acting material; yet it has more than a local interest, as most of our cities having a population of 30,000 to 40,000 own municipal garbage-reduction plants, and a considerable tonnage of tankage is therefore annually produced. A considerable amount of this material is contracted for by the commercial fertilizer manufacturer who uses it as a conditioner in fertilizer mixtures after it has been dried and ground. In this condition it is, of course, worth much more as a fertilizer than in its crude state. Of late there has been considerable inquiry regarding the value of the product, and requests for analysis are not infrequent. In its natural state it may be worth cartage to farmers living in the vicinity of the plant. The product may be used like farm manures, — from 5 to 6 cords per acre would not be an excessive application. It should be thoroughly worked into the soil with a disk harrow, and ordinarily should be accompanied by an application of lime. From 400 to 600 pounds of basic slag phosphate and 100 to 150 pounds of muriate or high-grade sulfate of potash per acre should be used to supplement it.

No. 6. Calcined Phosphate.
No. 7. Calcium Cyanamid.
No. 8. Sewage Tankage.

Analysis.

	No. 6.	No. 7.	No. 8.
Moisture,	-	2.23	7.30
Potassium oxide,	.59	-	.03
Total phosphoric acid,	32.06	-	1.62
Available phosphoric acid,	26.32	-	-
Calcium oxide,	36.99	40.00	-
Iron and aluminum oxides,	6.66	-	-
Sodium oxide,	7.40	-	-
Total nitrogen,	None	14.33	5.26
Water soluble nitrogen,	None	12.99	.40
Active water insoluble nitrogen,	None	.41	2.38
Inactive water insoluble nitrogen,	None	.93	2.48
Approximate commercial value per ton,	$23 25	$54 45	$16 65

Calcined Phosphate (*No. 6*). — Calcined phosphate, as the name indicates, is a manufactured product, high calcination being a part of the process. It is represented to be made under the so-called Newberry-Fishburne process, which, briefly stated, is as follows: —

A 30 to 32 per cent. phosphate rock is mixed with 15 to 20 per cent. of an alkaline salt. The mixture is heated in rotary kilns to a high temperature. During the process most of the salt is volatilized. The resulting porous clinker is pulverized and ground to a fine condition suitable for a fertilizer. The product gives a mild alkaline reaction.

Unpublished results at the Ohio and Indiana Experiment stations indicate that this material furnished phosphoric acid in an available form. The writer has not heard of the product being generally quoted in the fertilizer trade, and its cost is therefore not known.

Calcium Cyanamid (*No. 7*). — Calcium cyanamid, now generally handled in the trade under the name cyanamid, although not a new product is but rarely used by the farmer except as a part of commercial mixed fertilizers in which it is now not infrequently used. It is said that most of it is now bought by the fertilizer manufacturers. In view, however, of the large number of inquiries received concerning its nature, a short description may not be out of place.

Cyanamid is made by combining atmospheric nitrogen with calcium carbide at a high temperature, electricity being used as the heating agency. Two forms of cyanamid are now offered to the trade in this country, both being of a dark slate color. One is a fine powder, the other granular. The chemical composition of the two products seems to be about the same. The granular cyanamid possesses some advantages over the powdered form. It would be less dusty and disagreeable to handle, and probably could be used in larger proportions in mixtures with organic ammoniates and acid phosphates without causing loss of ammonia or serious reversion of the phosphoric acid. The nitrogen in cyanamid is largely soluble in water and in availability ranks well with sulfate of ammonia; it is not in the form of ammonia, however, but rather of an amide compound which is easily broken up in contact with water and becomes readily available in the soil. The product may be used as a quick-acting nitrogen source. Cyanamid may have an advantage over sulfate of ammonia in that it will not leave an objectionable acid residue in the soil as does the latter product. The residue left by cyanamid is a lime product which sooner or later will have a beneficial sweetening effect upon the soil. It would probably not be good practice to use more than 100 to 150 pounds of the cyanamid to the ton if the fertilizer mixture is likely to remain unused for a number of months. The free lime in the cyanamid will gradually cause a reversion of the soluble phosphoric acid. In the preparation of home-mixtures, which contain nitrate of soda, tankage, dry ground fish, blood, as well as other organic ammoniates, with acid phosphate and potash salts, a small proportion of cyanamid will be wisely included, as it favors the improvement of the mechanical condition of the mixture. It will aid materially in preventing the lumping of the fertilizer as well as the loss of nitrogen from the nitrate of soda under the influence of freshly prepared acid phosphate. These advantages will more than compensate any loss in the solubility of the phosphoric acid in the acid phosphate due to the action of the free lime in the cyanamid. This is particularly true if the proportion of cyanamid to the acid phosphate is not greater than 1 to 8 or 10. Cyanamid should not be used in the same mixture with ammonium sulfate, as free ammonia will be liberated from the latter salt. It should prove a valuable source of quick-acting nitrogen for most crops, but is not recommended as a top dressing for grass. It will not be found injurious when applied unmixed at the rate of 200 pounds per acre as a source of part of the nitrogen for tobacco.

Sewage Tankage (No. 8). — Sewage tankage, as the name indicates, is a product recovered from sewage by means of the precipitation method. In the sample here reported the grease was extracted from the dried material, which was then ground to a good mechanical condition. The sample analyzed carried about 78 per cent. of organic matter. Products of this character vary greatly in composition, as two samples examined at this laboratory in 1912 showed only .32 per cent. nitrogen, the phosphoric acid running 6.67 per cent. and the potash .78 per cent. Such a product would be valued commercially at about $5.50 per ton.

It has not been found commercially profitable to extract the fat from sewage tankage. The unextracted material has a very slow action in the soil, and practical experience does not encourage its use.[1]

No. 9. Picker Dirt from Cotton Mill, Average of Three Analyses.
No. 10. Cocoa-shell Dust.
No. 11. Shoddy Dirt from Woolen Mill.

Analysis.

	No. 9.	No. 10.	No. 11.
Moisture,	6.95	11.09	4.95
Potassium oxide,	1.56	2.71	.68
Phosphoric acid,	.68	1.49	.20
Total nitrogen,	1.37	2.94	4.40
Water soluble nitrogen,	.24	1.04	.12
Active water insoluble nitrogen,	.27	.51	2.41
Inactive water insoluble nitrogen,	.95	1.39	1.87
Approximate commercial value per ton,	$5 50	$9 50	$11 00

[1] See Monthly Bulletin, State Board of Health, Vol. 8, No. 12, December, 1913.

Picker Dirt from Cotton Mill (No. 9). — Picker dirt varies somewhat in composition; 19 analyses made at this laboratory show the nitrogen to vary from 1.55 to 1.60 per cent., the potash from .48 to 1.62 per cent., and the phosphoric acid from .08 to .68 per cent. The average commercial value on the basis of these analyses would be $3.75 per ton. The product would be slow in action when incorporated with the soil. Probably the most economical manner of using the material would be to add it at frequent intervals to the manurial matter in the manure pit; when used in this way it would retain a large amount of liquid manure and prove of value both as an absorbent and as a direct furnisher of plant food. It would not be a suitable material to use in the stable gutters on account of the dust, which would have a tendency to irritate the air passages and lungs of animals, and also because of the danger in carrying the germs of contagious diseases. A moderate application of lime should be used on the soil with this product, also about 400 pounds of basic slag or acid phosphate and 100 pounds of high-grade sulfate of potash per acre. The material will be found better adapted to corn and seeding to grass than to most other crops, and may be used at the rate of three cords per acre. It should be plowed in.

Cocoa-shell Dust (No. 10). — Cocoa-shell dust carries considerably more plant food than do ground cocoa shells, testing nearly a per cent. higher in nitrogen and phosphoric acid. The material may be used at the rate of 1 ton per acre. It should be supplemented by an application of 100 pounds of muriate of potash and 300 pounds of basic slag phosphate or acid phosphate.

Shoddy Dirt from Woolen Mill (No. 11). — Shoddy dirt will be found to vary considerably in composition. It is not a well-balanced fertilizing material, as it carries too little potash and phosphoric acid in proportion to the nitrogen. It may be used at the rate of 3 tons per acre applied broadcast and thoroughly wheel-harrowed in. For corn and seeding to grass 800 pounds of lime, 500 pounds of basic slag or acid phosphate and 150 pounds of muriate of potash should also be used per acre. On poor soils 100 pounds of nitrate of soda may be used to advantage when seeding to grass.

No. 12. Lime Refuse from Manufacture of Lactic Acid.
No. 13. Lime Refuse from Bleachery Filter Bed.
No. 14. Lime Refuse from Tannery.

Analysis.

	No. 12.	No. 13.	No. 14.
Moisture,	46.00	16.87	35.93
Calcium oxide,	19.23	42.43	24.80
Magnesium oxide,	.44	1.30	3.10
Nitrogen,	.30	-	.42
Sulfuric acid (SO_3),	27.50	-	-
Carbonic acid (CO_2),	.98	34.00	4.44
Insoluble matter,	.68	-	16.37

Lime Refuse from Manufacture of Lactic Acid (*No. 12*). — Lime refuse from the manufacture of lactic acid would not be a fit material to use agriculturally until mixed with 200 or 300 pounds of limestone per ton of refuse. The raw product carries nearly one-half of one per cent. of free sulfuric acid, which would probably injure vegetation unless neutralized by the limestone. The value of the product would not be over $2 to $3 per ton at the farm. After receiving the application of limestone the product should be used the same as land plaster or gypsum, as most of the lime is present as sulfate.

Lime Refuse from Bleachery Filter Bed (*No. 13*). — This particular sample contained practically all of its lime in the form of carbonate. It gave only a slight reaction for chlorides. In ordinary practice it would be well to apply the material during late fall and allow it to remain exposed until spring, so that any injurious lime compounds that might be present would have a chance to oxidize before being mixed with the soil. It may be used in quantities up to 2 tons per acre on land in need of lime.

Lime Refuse from Tannery (*No. 14*). — Most of the lime in this sample was present as hydrated or slaked lime. The product carries nearly one-half of one per cent. of arsenic (As_2O_5). If the product be used in moderate quantities (2 tons per acre) this amount of arsenic would probably not prove injurious to vegetation. It might, however, have a deleterious effect upon the beneficial soil bacteria. The sample has been submitted to the college bacteriologist, Dr. Marshall, who will later make some studies to decide this point. The opinion was expressed by Dr. Marshall that this small percentage of arsenic would not prove harmful when used as above specified.

In general, it might be said that these various refuse lime products, including the product from acetylene gas plants, may be used to advantage locally when they can be had for the hauling or at a small cost. It is usually the safest way to make the application of these products in the fall or winter, so as to allow a chance for the oxidation of any injurious compounds that may be present.

COCOANUT MEAL.

J. B. LINDSEY.

The cocoanut is the fruit of the cocoa palm (*Cocus nucifera*), growing in Ceylon, India, West and East Africa, the Philippine Islands, Brazil and Australia. It is valuable for its shell (which furnishes fiber), its oil and its meat. The milk in the inner part of the nut gradually becomes thick as the cocoanut ripens, and forms the meat of the nut. According to Ollech,[1] a typical ripe nut was found to consist of 30.45 per cent. of fiber, 19.59 per cent. of shell, and 49.96 per cent. of meat, and to weigh 1,133 grams. The oil is removed by pressure or by extraction by cooking with water, frequently at the place of production. The meat is shipped in a dry condition to Europe under the name of Kopra. The dry, unextracted meat (8 per cent. water) contains from 36 to 67 per cent. of oil.

The extracted meat is ground and furnishes the cocoanut meal used in animal feeding. When in normal condition it is light red to brown in color, has a nutty smell and taste, and is well liked by all kinds of farm animals.

The lot experimented with was secured from the Edible Oils Company of New York, who imported it.

1. Composition of Cocoanut Meal.

	Our Sample.	Average German Analyses.	Gluten Feed used in Experiment for Comparison.
Water,	9.00	10.50	10.40
Ash,	5.89	6.20	3.78
Protein,	19.35	21.40	23.37
Fiber,	8.64	14.70	6.82
Extract matter,	48.00	38.70	52.75
Fat,	9.12	8.50	2.88
Total,	100.00	100.00	100.00

[1] E. Pott, Handbuch d. Thierischen Ernährung, etc., Bd. III., p. 76.

Our particular sample contained rather less protein and fiber and more extract matter than the average of German samples. The latter, according to Kellner,[1] are sold on a guarantee of 18 per cent. protein and 12 per cent. fat. The gluten feed with which cocoanut meal is compared shows less ash and fat, rather more protein, and decidedly more starchy matter. The oil in the cocoanut meal very soon becomes rancid, and is converted largely into free fatty acids, giving a slightly unpleasant odor and taste.

2. Digestibility of Cocoanut Meal.

One experiment was conducted with two sheep, with the following results: —

	Our Sample.	Average German Analyses.	Gluten Feed for Comparison.
Dry matter,	–	80[2]	88
Ash,	64	–	88
Protein,	90	78	85
Fiber,	23	63	87
Extract matter,	87	83	90
Fat,	100+	97	81

Applying these coefficients to the analyses, we find the following amounts digestible in 2,000 pounds: —

	Cocoanut Meal (Our Sample).	Gluten Feed for Comparison.
Ash,	75.4	66.5
Protein,	347.6	397.2
Fiber,	40.4	118.6
Extract matter,	829.0	949.6
Fat,	187.4	46.6
Total,	1,479.8	1,578.5

It appears from the above results that the gluten feed furnishes about 100 pounds more digestible nutrients in 1 ton than the cocoanut meal. If, however, the fat in each case is con-

[1] Die Ernährung d. Landw. Nutzthiere, p. 359.
[2] Organic matter.

verted into its starch equivalent in the usual way, we find the cocoanut meal furnishes 1,705 pounds of digestible matter and the gluten feed 1,634 pounds. The cocoanut meal contains 88.4 therms of net available energy and the sample of gluten feed 82.7 therms. In case of gluten feed, Kellner requires a reduction of 10 per cent., making the therms 74.4 as against 88.4 for the cocoanut meal. It seems doubtful, however, to the writer if this 10 per cent. reduction is allowable. It hardly seems probable on the basis of composition and digestibility that the cocoanut meal would have a much greater nutritive value than would the gluten feed.

3. Feeding Experiment with Cocoanut Meal, 1911.

In order to test the relative efficiency of the cocoanut meal as compared with gluten feed as a component of a dairy ration, 10 cows were fed by the reversal method in periods of five weeks' duration. Hay and wheat bran constituted the basal ration to which were added definite amounts of either cocoanut meal or gluten feed.[1]

Table I. — *History of the Cows.*

Name.	Breed.	Age (Years).	Last Calf dropped.	Served.	Milk Yield (Pounds), Beginning of Trial.
Samantha,	Jersey-Holstein,	7	Aug. 15, 1910	Dec. 17, 1910	25
Amy,	Pure Jersey,	3	Sept. 20, 1910	Mar. 1, 1911	17
Gladys,	Pure Jersey,	7	Sept. 15, 1910	Aug. 14, 1911	21
May Rio,	Pure Jersey,	7	Dec. 5, 1910	Apr. 12, 1911	20
Betty,	Grade Jersey,	6	Oct. 22, 1910	Dec. 22, 1910	28
Betty II.,	Grade Ayrshire,	3	Dec. 8, 1910	Jan. 26, 1911	31
Fancy II.,	Grade Jersey,	3	Aug. 16, 1910	Dec. 22, 1910	18
Cecile,	Pure Jersey,	5	Nov. 1, 1910	Feb. 8, 1911	28
Ida,	Pure Jersey,	3	Sept. 5, 1910	Feb. 11, 1911	15
Red III.,	Grade Jersey,	5	Oct. 8, 1910	Dec. 14, 1910	28

[1] Cow Betty, being particularly thin, was given 1 pound of corn meal daily as a part of the basal ration in each half of the trial.

TABLE II. — *Duration of Trial, 1911.*

Dates.	Gluten Feed Ration.	Cocoanut Meal Ration.
January 6 through February 10, .	Samantha, Amy, Gladys, May Rio, Betty.	Ida, Fancy II., Betty II., Cecile, Red III.
March 11 through April 14, . .	Ida, Fancy II., Betty II., Cecile, Red III.	Samantha, Amy, Gladys, May Rio, Betty.

An unusually long time elapsed between the two halves of the trial (four weeks). This was due to the fact that several cows in the herd suffered a severe attack of scours, the cause of which could not be determined. It naturally interfered with the accuracy of the trial, although all of the cows were in good condition when the second half started, March 11. They had shrunk, however, rather more in yield than they would have had they not suffered the attack. Cows Amy, Betty II., Cecile and Betty were particularly affected.

Care and Feeding of Animals.

They were kept in roomy stalls, carded daily and turned into a protected barnyard for three to five hours each pleasant day. They were fed twice daily; the hay was given some time before milking in the afternoon and the grain just before milking, while in the morning the grain was given just before, and the hay just after, milking. Water was supplied constantly by aid of a self-watering device.

Character of Feeds.

The hay was largely Kentucky blue grass with considerable sweet vernal grass and some clover (early cut). During the last half of the trial the supply of this grade of hay became exhausted, and a mixture of timothy, red top and clover was substituted. It was of very good quality, but not as appetizing as the other variety. The animals refused some of the coarser parts and showed a tendency to shrink in milk. The bran was of the spring variety, and the gluten feed of good quality.

Weighing the Animals.

Each cow was weighed for three consecutive days at the beginning and end of each half of the trial, before the afternoon feeding.

Sampling Feeds and Milk.

The hay was sampled at the beginning and end of each half of the trial in the usual way, as described in other experiments of this character. The grains were sampled daily and the samples preserved in glass-stoppered bottles and brought to the laboratory at the end of each half of the trial for dry-matter determinations and complete analyses.

The milk of each cow was sampled daily for five consecutive days on the first, third and fifth week of each half of the trial. The usual method of sampling was followed.

TABLE III. — *Analysis of Feedstuffs.*

	Water.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.
Hay,	9.97	8.04	1.71	44.47	30.84	4.94
Bran,	11.97	16.10	1.36	55.99	9.23	5.33
Gluten feed,	10.28	23.39	2.88	52.82	6.83	3.79
Cocoanut meal,	6.49	20.05	15.07	44.98	8.43	5.06
Corn meal,	12.89	8.69	3.31	72.07	1.78	1.25

TABLE IV. — *Total Rations consumed by Each Cow (Pounds).*

Gluten Feed Ration.

	Hay.	Bran.	Gluten Feed.	Corn Meal.	Cocoanut Meal.
Samantha,	908	140	140	-	-
Amy,	625	105	140	-	-
Gladys,	695	105	140	-	-
May Rio,	695	105	105	-	-
Betty,	900	105	140	35	-
Ida,	689	105	105	-	-
Fancy II.,	522	100	100	-	-
Betty II.,	690	175	140	-	-
Cecile,	689	138	138	-	-
Red III.,	797	140	140	-	-
Totals for herd,	7,210	1,218	1,288	35	-

TABLE IV. — *Total Rations consumed by Each Cow (Pounds)* — Concluded.

Cocoanut Meal Ration.

	Hay.	Bran.	Gluten Feed.	Corn Meal.	Cocoanut Meal.
Samantha,	790	140	-	-	140
Amy,	514	99	-	-	133
Gladys,	624	105	-	-	140
May Rio,	672	105	-	-	105
Betty,	711	105	-	35	140
Ida,	764	105	-	-	105
Fancy II.,	481	105	-	-	105
Betty II.,	746	175	-	-	140
Cecile,	793	140	-	-	140
Red III.,	840	140	-	-	140
Totals for herd,	6,935	1,219	-	35	1,288

TABLE V. — *Average Daily Ration consumed per Cow (Pounds).*

Character of Ration.	Hay.	Bran.	Gluten Feed.	Cocoanut Meal.	Corn Meal.
Gluten feed,	20.6	3.48	3.68	-	1[1]
Cocoanut meal,	19.8	3.48	-	3.68	1[1]

The cows averaged .8 of a pound of hay more daily while on the gluten feed ration. This may have been due to the presence of the extra oil in the cocoanut meal satisfying the appetites. The different animals received from 16 to 26 pounds of hay, from 3 to 5 pounds of bran and from 3 to 4 pounds of gluten feed or cocoanut meal daily.

TABLE VI. — *Digestible Organic Nutrients in Average Daily Rations (Pounds).*

Character of Ration.	Protein.	Fiber.	Extract Matter.	Fat.	Total.[2]	Nutritive Ratio.
Gluten feed,	2.10	4.13	8.70	.32	15.95	1:6.5
Cocoanut meal,	1.92	4.00	8.12	.75	15.69	1:7.2

[1] For cow Betty only; not included in figuring average digestible nutrients.

[2] Including fat × 2.2.

It would appear, on the basis of the above calculations, which were made by applying average digestion coefficients to average daily rations consumed, that the two herds received substantially like amounts of total digestible nutrients. The cocoanut meal ration contained rather more fat and somewhat less extract matter than the gluten feed ration.

Herd Gain or Loss in Live Weight (Pounds).

Character of Ration.	Loss.
Gluten feed,	8
Cocoanut meal,	79

The difference is not of great importance. During the gluten feed period the 10 cows showed a total loss of 8 pounds, and during the cocoanut meal period a loss of 79 pounds. Cows Cecile and Betty II. were milking their maximum while in the cocoanut meal period, which took some flesh from their bodies.

Total Yield of Milk Products (Pounds).

Gluten Feed Ration.

	Total Milk.	Daily Milk.	Total Solids.	Total Fat.	Butter Equivalent (Fat+1/6).
Samantha,	876.3	24.8	135.74	54.59	63.69
Amy,	608.8	17.4	91.81	35.55	41.48
Gladys,	731.8	20.9	112.99	44.93	52.42
May Rio,	741.8	21.2	111.72	43.84	51.15
Betty,	902.8	25.8	128.65	45.05	52.56
Ida,	447.8	12.8	75.95	32.60	38.03
Fancy II.,	537.9	15.4	74.93	27.33	31.89
Betty II.,	827.2	23.6	115.89	39.54	46.13
Cecile,	793.5	22.7	113.39	39.91	46.56
Red III.,	810.5	23.2	113.31	44.33	51.72
Totals for herd,	7,278.4	20.81[1]	1,074.38	407.67	475.63

[1] Average daily yield.

Total Yield of Milk Products (Pounds) — Concluded.

Cocoanut Meal Ration.

	Total Milk.	Daily Milk.	Total Solids.	Total Fat.	Butter Equivalent (Fat+⅙).
Samantha,	698.8	20.0	110.62	47.10	54.95
Amy,	482.8	13.8	73.63	31.29	36.51
Gladys,	579.6	16.6	86.59	35.76	41.72
May Rio,	592.3	17.0	91.63	38.14	44.50
Betty,	720.3	20.6	103.72	38.68	45.13
Ida,	525.3	15.0	90.40	40.97	47.80
Fancy II.,	583.5	16.7	82.86	32.56	37.99
Betty II.,	1,124.8	32.1	155.00	56.46	65.87
Cecile,	991.5	28.3	145.65	56.22	65.59
Red III.,	902.3	25.8	129.48	54.68	63.79
Totals for herd,	7,201.2	20.6[1]	1,069.58	431.86	503.85

The 10 cows produced substantially the same amounts of milk and milk solids on both rations. In the case of the total milk fat the difference is somewhat in favor of the cocoanut meal ration (nearly 6 per cent.). This may have been due to the influence of the oil in the cocoanut meal.

Adverse Influences.

1. The attack of scours between halves.

2. The feeding of a new lot of hay during the last two weeks of the trial. The hay, however, was fed to each of the 10 cows so that all were treated alike.

3. While like amounts of gluten feed and cocoanut meal were fed to each herd the cocoanut meal contained 6.49 per cent. of moisture, while the gluten feed contained 10.28 per cent. During the entire experiment, therefore, the cows received 50.2 pounds more dry matter (.14 pound daily) in the form of cocoanut meal than in the form of gluten feed.

Inasmuch, however, as the cows ate rather less hay while receiving the cocoanut meal, and as the total digestible nutri-

[1] Average daily yield.

ents fed were slightly in favor of the gluten feed ration, it is probable that the small excess of cocoanut meal was without influence on the results.

General Conclusions.

1. Cocoanut meal is of the same general type of composition as gluten feed. It contains more fat, ash and fiber and noticeably less carbohydrate matter.

2. Cocoanut meal was found to contain about 100 pounds less digestible matter in a ton than the gluten feed. By converting the fat of the cocoanut meal into its starch equivalent, however, its nutritive value would be rather above the gluten feed. One hundred pounds of cocoanut meal contained 88.4 therms of net available energy as against 82.7 therms for the gluten feed. This is clearly due to the higher percentage of fat in the former.

3. Our feeding experiment with 10 cows shows substantially the same results in the amount of milk from the cocoanut meal and gluten feed ration; slightly more butter fat was secured on the former ration.

It is believed that the cocoanut meal is fully equal to the gluten feed in nutritive value, although it is doubtful if it exceeds it. German observers consider it particularly desirable for dairy animals in amounts of from 3 to 4 pounds daily per head, and it has been shown to somewhat increase the fat content of the milk. Fed in excess of the above it is held to make too hard a butter.

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